VIET NAM NATIONAL UNIVERSITY, HA NOI
CENTRAL INSTITUTE FOR NATURAL RESOURCE AND ENVIRONMENTAL STUDIES

# Proceedings of the Intenational conference on

# OCCUPATIONAL SAFETY, HEALTH AND ENVIRONMENT


VIET NAM PUBLISHING HOUSE OF NATURAL RESOURCES ENVIRONMENT AND CARTOGRAPHY

**VIET NAM NATIONAL UNIVERSITY, HA NOI**
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**Proceedings of the International conference on**

# OCCUPATIONAL SAFETY, HEALTH AND ENVIRONMENT (OSHE2024)

Ha Noi, Viet Nam October 24-26,2024

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# INTRODUCTION

*Dear delegates, experts and scientists,*

*Dear Conference participants!*

First, on behalf of the VNU- Central Institute of Natural Resources and Environment Studies, the Conference Organizing Committee, I welcome all distinguished guests, scientists, and delegates to the first Conference on Occupational Safety, Health and Environment - OSHE 2024.

*Ladies and gentlemen!*

Over the past few decades, the incidence of cancer due to environmental and occupational risk factors such as asbestos, arsenic, and indoor and outdoor air pollutants in high-income countries has decreased. However, these risks may increase for developing countries as industrialization expands and population grows. According to the World Health Organization, the three leading occupational risks for death in low- and middle-income countries are dust, injury, and cancer. According to estimates by the International Labor Organization, currently, every year in the world, up to 160 million people are sick, and about 2 million workers die from occupational diseases. In comparison, the number of deaths due to occupational accidents is about 360,000 people/year.

In 2010, the International Labour Organization issued a list of 105 occupational diseases, including: 56 diseases caused by exposure to hazardous factors in the workplace (chemicals, physical factors, microorganisms), 26 occupational diseases by affected body system (respiratory, skin, musculoskeletal disorders, mental disorders), 21 occupational cancers, and 2 other diseases. Annually, among nearly 2 million deaths related to occupational diseases, 25% are due to cancer, 21% are cardiovascular diseases, and 28% are infectious diseases. The damage caused by occupational diseases is significant.

In Vietnam, 35 occupational diseases are currently included in the list of insured occupational diseases. Some recent studies at medical facilities in the period 2016 - 2020 show that occupational diseases account for a high proportion in Vietnam, including noise-induced deafness (59.5%) and other pneumoconiosis (17.1%), as well as silicosis (11.9%). Occupational diseases have been and are reducing the working capacity of workers. In reality, accidents or illnesses related to work often have very high costs and leave many direct and indirect consequences on the health, income, and life of workers and their families. It also affects the production and business activities of agencies and enterprises where they work. To protect workers and for the sustainable development of enterprises, the harmonious development of society and the issues of environment, occupational health, and labour safety have been and are receiving significant attention from society. Research and training on occupational health and safety aim to help workers in all professions develop and maintain good physical and mental health, prevent damage caused by adverse working conditions, and protect and prevent harmful risk factors to their physical and psychological health. In addition, ensuring occupational safety, working environment conditions, workers' health in particular and public health, in general, are essential not only for workers and employers but also affect the quality of life of each family, the process of building and developing a safety culture in enterprises, and the sustainable development of the whole society. In the working environment, good implementation of safety, environment, and health will help minimize accidents, injuries, and health risks/hazards, reduce damage to life and property for workers, and ensure the prosperous development of enterprises and, by extension, the whole society.

*Ladies and gentlemen!*

Aiming for a prosperous and equal development in all aspects of economy - society - and environment, putting human development first, the Central Institute of Natural Resources and Environment Studies, Faculty of Environment, University of Science, Vietnam National University, Hanoi, with the sponsorship of Workplace Health Without Borders - United States Branch, organized the First International Scientific Conference on Occupational Environment, Health and Safety - OSHE.

This international Conference is a forum for domestic and foreign scientists, social and professional organizations, and management agencies to exchange, share knowledge and experience on research related to potential risks to workers' health caused by sources such as chemicals, radiation, and dust in the workplace or research on workers' mental health;

Share and jointly seek feasible and practical solutions/intervention methods to address adverse health risks not only for workers but also towards the sustainable development of businesses and employers;

Explore the need for continuous training to improve and enhance the capacity of occupational safety and health engineers with comprehensive knowledge of the environment, pollution control, occupational safety and health, waste treatment, and transportation for a developing economy.

In addition, the Conference also aims to build a network to promote research co-operation between domestic and international organizations through various academic exchange activities in occupational safety and health.

On behalf of the Organizing Committee, I hope that delegates and scientists will exchange and discuss solutions to improve environmental quality, occupational health, and safety, and build a society with a green, clean, and safe living and work environment.

Finally, on behalf of the Organizing Committee, I welcome delegates and scientists who have shown interest and taken the time to attend the Conference. I wish you good health and happiness and wish our Conference a great success.

**CHAIR OF CONFERENCE COMMITTEE**

**Assoc.Prof. Dr. Luu The Anh**

**VNU-Central Institute for Natural Resources and Environmental Studies (VNU-CRES)/ Director**

# Whole Body Vibration in Construction and Transportation

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**Abstract:** Driving trucks, buses, and other large vehicles is associated with whole body vibration (WBV) which, in turn, is associated withsignificant increases in musculoskeletal issues for drivers particularly in the neck and low back. The two main factors that affect WBV of the driver are speed of the vehicle and condition of the road surface. Although vehicle shock absorbers can dampen vibration, the main ways of reducing the amount of WBV that the driver receives is (1) limiting the amount of time spent driving, and (2) designing the seat to reduce the amount of vibration. Limiting the length of driving time is often not feasible for transportation enterprises for a variety of reasons including scheduling, training requirements, and efficiency demands. Currently available seating typically falls into three categories each with many variations: (1) a height-adjustable pedestal seat with no additional suspension controls; (2) a multi-adjustable seat which relies on air suspension to dampen WBV received by the driver; and (3) a multi-adjustable seat that relies on vibration-interference technology to cancel at least some of the WBV received by the driver. Although many companies in the developed world use air-suspension seating critical evaluation of their effectiveness compared to pedestal seating indicates that they do not protect against WBV significantly better than pedestal seating.

This presentation will review the musculoskeletal injury rate and prevalence of drivers globally; the various standards and regulations that govern exposure to WBV; various methods of measuring WBV including the importance of impulse vibration that occurs when hitting potholes, rocks, or other obstacles; and possible approaches for

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controlling the adverse effects of WBV in the transportation sector. A multifactorial, creative approach is best able to address the economic, psychosocial, legal, musculoskeletal, and organizational aspects of this widespread workplace risk.

*Keywords:* whole body vibration, trucks, buses, seating

## 1. Introduction

Although whole body vibration (WBV) can be experienced in a variety of industrial settings it is a serious risk for drivers of large vehicles used in construction, mining and transportation. WBV is associated with musculoskeletal injury particularly in the low back and neck resulting in pain which can be debilitating. Musculoskeletal injuries are among the most common occupational injuries both in the US and throughout the world. Data from the Bureau of Labor Statistics in the US [1] for the 2021-2022 fiscal year indicate that musculoskeletal injuries are the most common cause of days away from work and days with restrictions or transfers at work. These injuries occurred most frequently in the mining, construction and transportation sectors. Similarly, the International Labor Organization [2] reports that ergonomic factors are the third most prevalent cause of disability adjusted life years (DALYs) after occupational injuries and exposure to long working hours. Joseph et al [3] reported that 53% of individuals in a meta-study of 18, 882 professional drivers reported low back pain (LBP). Other areas with a high prevalence of pain included neck, shoulder and upper back. Chen et al [4] report that almost 60% of tractor drivers, 57% of taxi drivers, 53% of bus drivers, 52% of truck drivers and 30% of three-wheeled drivers reported LBP in their meta-study of 19,040 participants.

An Italian prospective study [5] of professional drivers of earthmoving vehicles, fork-lifts, garbage trucks, and buses used a four-part questionnaire to evaluate LBP during the previous 12 months. LBP was divided into three categories: pain/discomfort, high pain intensity, and disability. Increased exposure to WBV was associated with the risk of LBP, but the association was stronger when pain intensity and/or disability from pain were used as a variable.

In a 2013 study [6] WBV was compared between a high-floor and a low-floor bus. Each type of bus travelled the same route which contained old and new highway segments and city streets, some with speed bumps. Seating attenuated only 10% of the floor transmitted vibration. WBV was similar in both bus types except that the high-floor bus transmitted more WBV going over speed bumps.

A systeatic review [7] of professional (bus, truck and taxi) drivers reviewed physical (WBV, awkward/sustained postures, lifting tasks, bending/twisting task, and manual material handling), psychosocial (perceived job stress/demand, low job satisfaction, and reward imbalance), and individual (age, BMI, smoking, alcohol use, education level, gender, and level of physical activity) risk factors and their association with the development of work-related musculoskeletal disorders (WRMSD). The location of the WRMSD was not specified but the authors report a strong correlation, using the Bradford-Hill criteria, between WRMSD and exposure to whole body vibration, awkward postures, perceived job stress/demand and previous MSD injury. The average odds ratios reported in publications describing a relationship between WBV and WRMSDs ranged from 1.3 to 4.9.

## 2. Measurement of WBV

Vibration has wave properties which means both the frequency and the amplitude of the displacement is measured. When measuring occupation WBV a triaxial accelerometer plate is placed on the seat underneath the driver to measure displacement along the x, y, and z axes. Once the data is collected in $m/s^2$ weighting curves are applied to reflect the human sensitivity to vibration at different frequencies. The weighting curves are the same in the x and y dimensions but slightly different in the z dimension. The weighting function for vibration is analogous to the weighting curves used during noise measurement, for example, the A weighting curve.

More sophisticated academic evaluations will measure the vibration at both the floor of the vehicle and at the interface between the seat and the driver. In this case two triaxial accelerometers are used. This type of measurement is particularly useful when trying to ascertain the dampening effectiveness of the seat.

## 3. Standards and Guidelines

Although there is no enforceable standards for WHB in the US, the American Conference of Governmental Industrial Hygienists (ACGIH) recommends an action level of 0.43 $m/s^2$ below which there is a very low probability of adverse health effects. It also defines an exposure limit, called a threshold Limit Value TLV), of 0.87 $m/s^2$ for an 8-hour exposure. Exposures greater than the TLV are associated with increased probability of adverse health effects. If an individual's exposure level falls between the action level and the TLV careful assessment of symptoms should be conducted to identify incipient adverse effects before they develop into debilitating injuries.

ISO, an international standards setting body, also has whole body vibration guidelines (ISO 2631-1) that recommend 0.9$m/s^2$ as a maximum level of vibration for an 8-hour period, and 0.45 $m/s^2$ as the action level above which interventions to reduce WBV should be initiated. The ISO values are essentially the same as the ACGIH values for WBV. The International Standards Organization (ISO) recommends determining the length of daily exposure, measuring the actual vibration the driver receives through the vehicle seat, calculating daily WBV, and comparing it against daily vibration exposure limits. WBV can be measured as a root-mean-square of acceleration in $m/s^2$ or as a vibration dose value in $m/s^{1.75}$. The crest factor, derived from the frequency-weighted acceleration signals, is the peak vibration measured divided by the root-mean-square. The root-mean-square is appropriate when the vibration is a steady state exposure. The vibration dose value is appropriate when there are transient events, impulses or shocks.

The European Union promulgates exposure limits for WBV which include an action level of 0.5 $m/s^2$ and a maximum exposure limit of 1.15 $m/s^2$ for an 8-hour work shift.

## 4. Seating Options to Control WBV

One of the main ways to control

WBV in drivers of trucks, buses and heavy equipment is to install better seating. Seating for trucks, buses and heavy equipment is traditionally divided into three types: (1) passive seat suspension, (2) semiactive seat suspension, and (3) active seat suspension. There are basically four types of seating technologies used in trucks, buses and heavy equipment:

1. Traditional seating - passive
2. Air-ride seating - semiactive seat suspension
3. Magnetorheological (MR) seating - active seat suspension
4. Vibration cancelling seating - active seat suspension.

Traditional seating, sometimes called pedestal seating, is simply a seat pan on a stick. The height may be adjustable up and down but not much else is adjustable. The seat pan may have a back rest, but older equipment may not. Most seating in the US, Canada and Europe is either semi-active or active in buses and trucks, but heavy equipment seating used in construction and mining may be passive. Globally, seating in transportation as well as construction and mining is often passive.

Air-ride seating, the current industry standard in the US, relies on a cushion of air in addition to steel coils and springs in the seating to dampen vibration. Flexible air compartments built in under the seat allow the drivers to adjust height and firmness of the seat by controlling the amount of compressed air in the air bag. This type of system requires an air compressor on the vehicle and allows the driver to adjust the seat depending on road conditions, body weight, and personal preferences. Air ride suspension seating also typically offers a large range of ergonomic features sure as back rest, head rests, lumbar support and arm rests as well as a wide range of adjustability, not only up and down and forward and backward, but also in the positioning of head, back and arms rests as well as the lumbar support.

MR seating relies on magnetorheological (MR) fluids which contain iron particles suspended in oil or a carrier fluid. When a magnetic field is generated the iron particles line up along the direction of the magnetic field and transform the liquid to a semi-solid state. The transformation which occurs within milliseconds requires an external power source to generate and control the magnitude of the magnetic field. Magnetorheological fluids have been used in a variety of applications including bus, truck and heavy equipment seating because of their vibration dampening, simple design, low power usage and cost-effectiveness [8]. Improved control of magnetic field generation can enhance the ability of MR seating to control high impact jolts from potholes and other highly uneven surfaces.

Vibration cancelling technology, analogous to noise cancelling ear protection, has been applied to seating for heavy duty vehicles. A highly responsive electromagnetic linear actuator can be used to control up and down motion associated with driving trucks and buses. Because of the short response time the attenuator can produce the reverse of the incoming vibration before it is transmitted to the driver. Research is ongoing to improve the effectiveness of active seat suspension technology [9].

In addition to these types of seating, various types of cushions and support add-ons have been used with the goal of making drivers of trucks, buses and heavy equipment more comfortable and of reducing musculoskeletal pain and injury [10]. Many of these reports rely on driver surveys but do not include WBV measurements, despite WBV for extended periods of time being one of the main conditions associated with neck and/or back pain and disability.

## 5. Discussion

WBV is one of the main factors associated with neck and low back pain in truck, bus and heavy equipment drivers. One of the main ways to mitigate WBV is through seating, but all seating is not equally effective. Although there are many testing protocols in designing seats for trucks, busses and heavy equipment few field evaluations have been reported. Field evaluations using triaxial accelerometers consistently indicate that different types of seating, and even different seats within the same type, provide varying levels of vibration mitigation. Lewis and Johnson [11] reported that air-suspension seating did not reduce the amount of road vibration transmitted to the driver. Another study of active suspension and passive air suspension seats in semi-trucks [12] reported that the truck drivers with the active suspension seats had a 50% lower WBV and experienced a "clinically meaningful 30% reduction in self-reported low back pain." A more recent study [13] evaluated three types of bus driver seats: active suspension, industry standard air-suspension, and a height adjustable suspension-less pedestal seat. The measured WBV was 40-60% lower in the active suspension seat compared with the other two types of seating.

A recent study compared three semi-passive air-ride seats and one active seat suspension in 24 male truck drivers using two triaxial accelerometers, one on the floor of the truck and the other between the driver and his seat. The 280 Km, 10 to 11- hour route that included both paved and unpaved roads. Both the rms 8-hour average and the vibration dose value were evaluated. In many cases the drivers reached the ISO 8-hour limit before they had driven 8 hours. There was significant variation in the WBV attenuation among the three semi-passive air-ride seats. The active-suspension seat was significantly better in attenuating WBV received by the drivers than the semi-active air-ride suspension seating [14].

Vehicle suspension systems as well as road surface and how fast the vehicles is traveling affect the intensity of WBV. Highways are typically well-paved, but they also allow heavy trucks and buses to travel at higher speeds. Although city streets are paved, they often contain unavoidable potholes which result in large spikes of vertical displacement. Off-road conditions which occur on construction sites and in mining operations, increase the amount of WBV conveyed to drivers of vehicles traversing them because they are typically unpaved with ruts, rocks, and other debris.

Although the US has no enforceable WBV limit the ACGIH and the ISO guidelines for WBV exposure in drivers are very consistent. The European guidelines are slightly more lenient. When field WBV measurements are taken the ISO and ACGIH exposure limit is often exceeded before 8 hours of driving is completed which means drivers are likely to develop neck and/or low back pain. In reality, most professional drivers drive more than 8 hours per day. Frequently field evaluations of WBV exceed the action limit in both the ISO and ACGIH guidelines which indicates that drives are at risk of developing neck and/or low back pain and corrective action should be taken.

This suggests that another way to limit WBV in professional drivers is to limit driving time. Limiting driving time does not work well for several reasons including disruption of schedules and reduced productivity. Trucks and buses have delivery schedules for goods and people, respectively. Those schedules are often interrupted by events over which the driver and the company have little control. Traffic, weather, and other factors interfere with and typically lengthen both truck delivery times and bus schedules. The driver needs to stay with the vehicle until the route is completed. In addition, drivers are typically paid by the hour so reducing driving time reduces pay. Drivers are not typically prepared to work at other types of employment within a company.

Engineering controls such as effective vibration dampening seating to reduce WBV are essential, but it is also important to look at other factors associated with the development of spinal pain and disability. Disabling neck and low back pain is multifactorial and are associated with prolonged sitting, lack of exercise, psychosocial stress, and individual factors in addition to WBV. Raffler et al [15] have reported that WBV exposure combined with awkward posture are associated with a significant increase in LBP. Some studies, but not all, have identified personal risk factors such as age, overweight, high blood pressure and stress as important contributors to the development of back pain.

A Croation paper [16] studied the correlation between the number of steps taken daily with low back pain in bus drivers concluded that "….physical activity mitigates [mediates] the effect of the non-ergonomic position of the upper body segments on the musculoskeletal health level; a higher level of physical activity could promote the health of the musculoskeletal system in non-ergonomic working conditions among bus drivers." The average number of steps taken by bus drivers over four days of measuring with a pedometer was 5,000 with a range of 965 to 18,300. Those with the larger number of steps reported low pain scores on the Orebro Musculoskeletal Pain Questionnaire. The number of daily steps recommended for a healthy lifestyle is in the range of 7,000 to 10,000, about 4 or 5 miles.

An Indonesian review of musculoskeletal injuries in bus drivers globally concluded that divers with a low level of physical activity had a higher risk injury [17].

## 5. Conclusion and Recommendations

WBV is an important contributor to the development of back pain and disability in truck, bus and heavy equipment drivers. Although this is widely acknowledged there are very few field measurements of the amount and type of WBV that is experienced by these drivers in the performance of their jobs. Despite the importance of reducing the amount of WBV transferred to drivers through their seating, it is also essential to incorporate consideration of other factors that are associated with neck and back pain, such as prolonged sitting, lack of exercise and stress.

In view of these considerations the following steps are suggested to improve the occupational health of truck, bus, and heavy equipment drivers:

Focus on effect seating design by quantifying WBV transmitted to drivers for each type of seating used during field evaluation.

Quantify costs associated with different types of seating including.

Replacement and maintenance costs.

Direct injury costs.

Indirect injury cost such as absenteeism, presenteeism, and training new personnel.

Integrate other approaches, such as exercise opportunities, healthy living advice, adequate pay for drivers.

Assess effects of road condition, speed of vehicle, type of tires and vehicle suspension in addition to seating.

Evaluate the effectiveness of each intervention both in terms of driver health and well-being and company productivity and profits.

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**References**

1. Employer-Reported Workplace Injuries and Illnesses - 2021-2022, Bureau of Labor Statistics, US Department of Labor
2. https://www.bls.gov/news.release/pdf/osh.pdf (accessed 29 September 2024)
3. International Labor Organization (ILO) A call for safer and healthier working environments,2023 https://www.ilo.org/publications/call-safer-and-healthier-working-environments (accessed 29 September 2024)
4. L. Joseph, M. Standen, A.Paungmali, R. Kuisma, P. Sitilertpisan, U.Pirunsan, Prevalence of musculoskeletal pain among professional drivers: A systematic review, J Occ Health 62 (2020) 17 pages.
5. C.Chen, B.Xiao, X.He, J.Wu, W.Li, Low back pain in professional drivers: a meta-analysis, Public Health 231 (2024) 23-30.
6. M.Bovenzi Metrics of whole-body vibration and exposure-response relationahip for low back pain in professional drivers; a prospective cohort study, IntArch Occup Environ Health (2009) 893-917.
7. O.Thamsuwan,R.P. Blood, R.P.Chang,L.Boule, P.W.Johnson, Whole body vibration exposure in bus drivers: A comparison between a high-floor coach and a low-floor city bus, Internatl. J. Industr. Ergon. 43 (2013) 9-17.
8. L.Joseph, L.Vasanthan, M.Standen, R.Kuisma, A.Paungmali, U.Pirunsan, P.Sitilertpisan, Causal Relationship Between the Risk Factors and Work-Related Musculoskeletal Disorders Among Professional Drivers: A Systematic Review, Human Factors 65 (2023) 62-85
9. M.A.Aziz, S.M. Mohtasim, R.Ahammed, State-of-the art recent developments of large magnetorheological (MR) dampers: a review, Korea-Australia Rheology Journal 34 (2022) 105-136.
10. Alfadhli, J. Darling, A.J. Hillis, An Active Seat Controllor with Vehicle Suspension Feedforward and

Feedback States: An Experimental Study, Appl. Sci. 8(2018)603-625 . https://doi.org/10.3390/app8040603

11. J.W. Lee, Y.H. Lim, Y.H. Won, D.H. Kim, Effect of glsssst cushion on chronic low back pain in Occupational drivers: a double-blind controlled trial, Medicine 97 (2018) 40-45. https://doi.org/10.3390/app8040603
12. C.A. Lewis, P.W.Johnson, Whole-body vibration exposure in metropolitan bus drivers, Occupational Medicine 62 (2012)519-124 doi:10.1093/occmed/kqs096
13. P.W. Johnson, M. Zigman, J. Ibbotson, J. Dennerlein, J.H. Kim, A Randomized Controlled Trial of Truck Seat Intervention: Part I: Assessment of Whole Body Vibration Exposures, Annals of Work Exposurs and Health 62 (2018) 990-999.

# Board of Global EHS Credentialing - An Overview

Donald M. Weekes*

*CIH, CSP, FAIHA**

*Member, Board of Directors, BGC*

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**Introduction**: This presentation will discuss the environmental, health and safety credentials managed by the Board of Global EHS Credentialing (BGC), with a focus on the Certified Industrial Hygienist (CIH) credential. The presentation will also discuss the other credentials that BGC offers. These credentials include Qualified Environmental Professional (QEP); Certified Professional Environmental Auditor (CPEA); Certified Professional in Environment, Safety and Health (CPESH).

**Outline of Topics:**

History of BGC (formerly ABIH).

Scope of current certifications BGC is managing.

Benefits of Certification for the public, professionals, and employers.

How BGC is improving the Global aspects of their certification activities.

History of ABIH/BGC:

The American Board of Industrial Hygiene (ABIH), the predecessor of the Board of Global EHS Credentialing (BGC) was incorporated in Pittsburgh, Pennsylvania in 1960. In 2019, the ABIH-Board changed the organization's name to the Board for Global EHS Credentialing (BGC), and the industrial hygiene (IH) credentialing division became known simply by the acronym "ABIH."

The Mission and Vision of BGC reflect the expansion of BGC credentials in the past few years to include environmental, product

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safety and environmental auditing. The Mission is as follows: 'We protect people and the environment worldwide by providing precise and rigorous credentials for essential environmental, health and safety professionals. The Vision of BGC is: 'A healthy and thriving world made better by BGC credentialled professionals.'

The Mission and the Vision of BGC are the goals we have set regarding the management of all the BGC credential. These credentials can only be obtained by a rigorous process, including exams for each credential.

Scope of current BGC certifications.

BGC Credentials Focus on Four Areas:

People.

Places.

Things.

Systems

People; CIH

Certified Industrial Hygienists (CIHs) protect the health and safety of workers and the public in their workplaces, homes, and communities to prevent avoidable injuries and accidental death from chemical, physical, biological, and ergonomic hazards. This is the 'gold standard' for professionals working in the occupational health and safety fields.

The CIH is the most popular EHS credential worldwide. It also has the largest number of practitioners outside of North America in China (PRC, HK Taiwan). For an examination update, including test facilities; exam window; details on the credential process; This information is available online as well as at testing facilities. https://gobgc.org/cih/

The CIH application and exam requirements:

**Education:** U.S. Bachelors' Degree or equivalent.

**Sciences** (e.g. Chemistry, Physics, Biology, Engineering)

**Safety** (ABET accredited)

Industrial/Occupational Hygiene (ABET accredited)

180 academic hours or 240 Continuing-Education (CE) hours in industrial hygiene. 50% or more of the hours must cover the Fundamentals of IH, Toxicology, Measurements and Controls. There is also a 2-hour ethics course

requirement.

**Experience:** 3 - 4 years IH experience in 2 of 4 stressors below.

Chemical; Physical; Biological; Ergonomic.

**References:** Minimum: 2 references (including 1 CIH or equivalent).

**Examination**: 5 hours with an optional 30-minute break. 150 scored items, 30 pilot-test items.

**Places**: QEP; EPI

Qualified Environmental Professionals.
(QEPs) and Environmental Professionals In-Training (EPIs) develop creative and effective solutions to reduce the impact of human activity on air, water, and soil for a cleaner and healthier environment.

The QEP Application & Exam requirements:

Education by Work Experience:

Bachelor's degree in science plus 5 years work experience in this field.

Bachelor's degree in other fields plus 8 years work in this field.

**Experience**:

5 Years of experience

**References**:

3 Character references

**Exams**:

100 questions per exam

3 hours per exam

**Pt 1**: General Environmental Science Exam.

**Pt 2**: Specialty Exam

Air Quality

Water Quality

Waste Management

Environmental Science, Management & Policy

Things: CPPSs

Certified Professional Product Stewards (CPPSs) are responsible for the management of raw materials, intermediate materials, and consumer products to maximize value, while minimizing or preventing negative impacts to human health, safety, and the environment.

If you are interested in becoming certified as a CPPS, you must meet six requirements:

You must have a bachelor's degree from a regionally accredited college or university or from another college that is acceptable to the Board.

You must have 48 months (four

years) of professional-level experience where at least 50% is in the professional practice of product stewardship.

You must currently be engaged in active practice at the time of application.

You must pass the CPPS exam.

You must agree to adhere to the BGC Code of Ethics and to be governed by the BGC Ethics Case Procedures.

**Systems**: CPEAs and CPSAs:

Certified Product Environmental Auditors (CPEAs) and Certified Professional Safety Auditors (CPSAs) will be combined into a single CPEA certification in the Spring of 2025. The purpose of the CPEA certification is to ensure that operating and management systems are in place and followed to protect human health, safety, and the environment.

The CPEA credential demonstrates one's practice of today's ever-changing environmental, health & safety regulations through four specialties: Environmental Compliance, Health and Safety, Management Systems, Responsible Care® and related auditing procedures, processes, and auditing techniques. CPEAs also qualify for Professional Membership status with the American Society of Safety Engineers (ASSE). The CPEA credentialing program is fully accredited by the Council of Engineering and Scientific Specialty Boards (CESB).

**Education**:

Bachelor's degree

**Training:** 40 hours in the last 3 years

**Experience:** 4 years' work experience

**Experience:** 20 EC, HS, MS audits (100 days) over the last 4 years. (20 days must have been on site); RC EMS-related audits totaling 20 days within 2 years of certification.

**References:** 2 Character references with 2 years of knowledge of your EHS auditing experience and skills.

For more information: https://gobgc.org/cpea/

Certification Process for all Credentials

The certification process has five (5) steps.

You first apply for certification by providing documents about your education and work experiences to BGC staff. Some documents must come directly from your university if you have been granted a degree.

If your application is approved, you will be allowed to sit for the exam. If you fail the exam, you may have to reapply for another test.

Use the Pearson Vue website to access the site to take the exam. https://www.pearsonvue.com/us/en/bgc.html

When you have passed, you will have to maintain your credential through continuing education. You will also have to uphold the BGC cold of ethics. If you fail to maintain your credential or live up to the code of ethics, you may lose or must give up your CIH credential.

Finding a Test Center

Pearson Vue has test centers through the world when you can take the CIH exam currently. Here is their website for finding a test center near you:

https://wsr.pearsonvue.com/testtaker/registration/SelectTestCenterProximity/METACRED?conversationId=636464

Pearson Vue has test locations in Ho Chi Minh City and Hanoi, Vietnam.

Use the link to locate the Pearson Vue testing location nearby.

Online Testing for CIH Exams

https://www.pearsonvue.com/us/en/bgc/onvue.html

Webpage (Pearson Vue) provides info as follows:

Test Scheduling and Remote proctoring

Before Test Day - Checking your system.

Choose a distraction-free location.

Get your ID ready

Test Day -

Last-minute prep.

Check in on the website.

Start your exam.

Spring, 2025 - Two new Credentials.

Certified Professional in Environment, Safety, and Health™ (CPESH™)

Certified Associate in Environment, Safety, and Health™ (CAESH™)

CPESH™ must be able to

perform a multi-disciplinary evaluation of: occupational and environmental health and safety hazards and risks, environmental aspects and impacts, sustainability, concepts relating to regulatory and voluntary standards and risk mitigation.

CPESH™ applicant must have obtained at least a Bachelor of Science in the science, technology, engineering, or mathematics (STEM) field and have at least 5 years of experience. Consideration may be given to substitute 6 months of experience if the degree is from an applicable ABET or EHAC-accredited degree program.

CAESH™ must have a multi-disciplinary understanding of: occupational and environmental health and safety hazards and risks environmental aspects and impacts sustainability concepts relating to regulatory and voluntary standards and risk mitigation

CAESH™ applicant must have a total of 4 years of a combination of education and experience. This could include academic or continuing education course equivalents in EHS-related topics or EHS experience.

Practitioner Benefits

Certification holders benefit from: Greater confidence in their professional competence

Increased professional trust from employers or the public

Better compensation and career longevity

Increased recognition by peers and respect of colleagues in the profession

Improved opportunities for employability and advancement

Consumers (Public)benefit from: Objective, independent, third-party evaluation and assessment of professional competence

Commitment to public safety and/or consumer protection Accountability through ethical conduct standards and/or a disciplinary process

Recertification requirements for continued or enhanced competence

Employers benefit from: Identification of Qualified individuals for employment or advancement

Recertification requirements for continued or enhanced competence

Commitment to public safety and/or consumer protection

Reduced risk of errors, accidents and/or legal liability

Reduced employee turnover and increased job satisfaction

Justification for potential compensation differential

Steps to Facilitate Global Access

Updating all exams to allow for remote proctoring

Assessing question banks to remove unintentional bias such as regional regulatory emphasis

Eliminating exam testing windows

Streamlining application process

BGC understands the importance of impartiality in carrying out its certification activities, so the Board and staff manage conflicts of interest and ensure the objectivity of all certification activities. BGC will evaluate all applicants and Certificants using the criteria established and will not discriminate on the basis of race, creed, national origin, religion, age, disability, political affiliation, sex, sexual orientation, or marital, parental, military, or any other legally protected status.

# InTERACCT: Training in Industrial Hygiene and Emerging Technologies

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**Abstract:** The Interdiscipllinary Training, Education and Research Activities for Assessing and Controlling Contaminants from Emerging Technologiest (InTERACCT) has the goal of building an occupational health and safety workforce capable of anticipating and preventing hazards from emerging technologies, including: additive manufacturing, nanotechnology and novel drug delivery. Towards this goal, InTERACCT investigators are developing asynchronous on-line courses targeting graduate students and practicing professionals that convey core principles of chemical hazard recognition, exposure assessment, and risk assessment, with case studies focused on emerging technologies. Each core principles course involves 10-12 modules developed by industrial hygiene professors and educational specialists at three American universities. Each module is developed for accessibility and includes a written transcript, in addition to an audio narration over presentation materials that include graphs, tables, animation and video recordings. These courses are able to be integrated into academic programs, and are being adapted for continuing education. In addition, InTERACCT has provided research training opportunities for graduate students, and launched a week-long introduction to industrial hygiene for undergraduate students in Science, Technology, Engineering and Math (STEM).

*Keywords:* industrial hygiene, continuing education, emerging

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Technologies, adult education

## 1. Introduction

Emerging technologies, including nanotechnology, additive manfacturing and novel drug delivery methods, are being rapidly adopted in the workplace. The short time interval between technology development and adoption can be a challenge to occupational health professionals to anticipate, recognize, assess and control exposures before they pose health risks to workers. Occupational hygienists and other occupational health professionals can be best prepared for this situation by having strong foundational competencies and familiarity with examples of successful management of emerging technology hazards in the workplace. The Interdisciplinary Training, Education and Research Activities for Asessing and Controlling Contmainants from Emergency Technologies (InTERACCT) seeks to prepare occupational hygienists and other occupational health professionals for this challenge.

InTERACCT brings together faculty and learning specialists from three American universities - the University of Minnesota, the Univeristy of Iowa and the University of California, Los Angeles, to build a health and safety workforce ready to anticipate, recognize, assess and control familiar and novel health risks from emergint technologies. This is achieved by: developing educational materials for graduate students and practicing occupational health profesionals, providing research training opportunities for graduate students, and introducing undergraduates to educational and career opportunities in occupational hygiene and health.

The objective of this paper is to describe the activities of InTERRACT to date so as to increase awareness and utilization of available training materials. The focus herein is on the Chemical Hazard Recognition Course, one of three planned core courses to develop foundational competencies that is complete. Other activities will be highlighted.

## 2. Course Development

### *2.1. Audience*

The intended audiences of the core courses and case studies are graduate students in occupational hygiene or related disciplines and practicing professionals.

*2.2. Modality*

The core courses were planned to first be distributed at no cost for asynchronous online learning. Materials available to the learner were planned to include: an audio naration over a slide deck or video recorded demonstration, a transcript of the narration that included any figures or tables from the slide deck, and the slide deck in Portable Document Format (.pdf).

Two platforms were identified for dissemination 1) the InTERACCT YouTube channel (https://www.youtube.com/@interacct_umn) and 2) the InTERACCT program webpage hosted by the University of Minnesota Exposure Science and Sustainability Institute

(https://essi.umn.edu/interacct/)

*2.3. Branding*

To reduce unauthorized use of intellectual property and increase recognition of the program, a logo, slide deck templates and transcript templates were developed for use in InTERRACT courses. The free modules can be repurposed and integrated into training and adapted through a Creative Commons license.

*2.4. Competencies and Learning Objectives*

Drawing upon their technical expertise and experience with education, the investigators worked together, through iterative group discussion to define competencies for the course. From these comptencies, the course was divided into modules, and learning objectives were developed for each module that scaffold learners to achieve the comptencies.

*2.5. Course Design Strategy*

An iternative process incorporating peer-review for technical content, educational effectiveness and accessibility was employed for course design. Briefly, the lead module author, an occupational hygienist, drafted an outline that was reviewed for technical aspects before developing the slide deck and narrative. Graphics and animations were developed by an artist and added to the slide deck. The narrative and slide deck were reviewed by an instructional designer for effectiveness and accessibility, and by an occupational hygienist for technical content. Feedback was incorporated through revision before recording the narrative, and the materials were edited to assemble the final product.

## 3. Chemical Hazard Recognition Core Course

The five comptencies that learners should be able to demonstrate upon completion of the Chemical Hazard Recognition course are listed inTable 1. The course modules are shown in Table 2, each of which includes 1-3 parts. Each course module has learning objectives that are specified at the beginning of each module or module part. The course modules need not be completed in sequence.

Table 1. Chemical Hazard Recognition Course Competencies

| No | Competency |
|---|---|
| 1 | Identify potential hazards associated with different classes of chemicals |
| 2 | Use a range of data visualization tools to both learn and teach others about these hazards |
| 3 | Explain qualitatively and quantitatively the factors governing the generation and dispersal of chemical agents and recognize potential tasks and environments in which chemical exposures may be especially hazardous |
| 4 | Describe how the properties and behavior of chemicals influence their impact on human health |
| 5 | Support assessment of exposures to meet conventional industrial hygiene and future population-based study needs by documenting specific information about chemical hazards, such as from databases and the scientific literature |

Table 2. Chemical Hazard Recognition Course Modules

| Module Title | No. Parts |
|---|---|
| Sources of Information | 2 |
| Foundational Principles of Health Hazard Evaluation | 2 |
| Technology Overview | 3 |
| Using the IHEST Tool | 1 |
| Properties of Liquids, Gases and Vapors | 2 |
| Aerosol Properties | 1 |
| Using the Structured Deterministic Module 2.0 | 3 |
| Exposure Routes: Gases and Vapors | 1 |
| Data Handling, Cleaning and Formatting | 1 |
| Spatial Data Techniques and Dispersion Patterns | 2 |
| Selecting Appropriate Occupational Exposure Limits | 2 |

Several modules include video recordings that demonstrate how to use websites to gather information or how to use specialized tools developed for occupational hygiene practice. Some modules include animations to provide enhanced explanation of biological, chemical or physical processes relevant to occupational exposures. The Technology Overview module provides explanations of additive manufacturing processes, an emerging technology, and provides an exercise for learners to practice applying foundational skills learned in the course to additive manufacturing technology of vat photopolymerization.

The Chemical Hazard Recognition course modules were completed and posted at the end of 2023, and have been viewed hundreds of times. The most popular modules are the Using the Structured Determininistic Module 2.0 and the Using the IHEST Tool, which have been viewed 444 and 177 times to date, respectively

## 4. Other Activities

InTERRACT investigators have been engaged in a number of other activites.

### *4.1. Student Training*

Two doctoral students at the University of Minnesota have been engaged in research experiences on themes related to InTERRACT: One manuscript has been published from this work [1], and another is submitted.

In June 2024, the University of Minnesota hosted a week long summer program for undergraduate students that drew five participants. The program included hands-on activities in the laboratory, field trips, learning about graduate school, leadership training and an opportunity to meet professionals and graduate students.

### *4.2. Further Course Development and Dissemination*

Two more core courses are under development. Competencies and learning objectives have been developed for the Exposure Assessment core course, and the authors are developing the slide decks and narratives. Planning is beginning for the Risk Assesment core course.

The Chemical Hazard Recognition course is being adapted for dissemination as a continuing education course. As a continuing education course, learners will pay a fee but will be able to claim continuing education credit for professional certification.

Investigators in InTERACCT have begun integrating the Chemical Hazard Recognition course into their academic programs, and will be promoting the modules for integration into courses at other academic institutions.

## 5. Conclusion

InTERACCT has developed education and training materials that are accessible to a wide audience at no cost. The program has led to professional development for its investigators, and future evaluation will assess its impact on learners. Occupational hygiene is a dynamic profession owing to innovations in workplace technologies, motivating continous improvements in graduate education and continuing education for practicing professionals.

## Acknowledgments

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## References

1. P. Moshele, M.R. Stenzel, D. Drolet, S.F. Arnold. Comparing Antoine parameter sources for accurate vapor pressure prediction across a range of temperatures. Ann Work Expo Health. 68 (2024). 409-419..

# Monitoring of PBDEs using passive air samplers (PUF) in air samples collected from urban areas in Hanoi, Vietnam

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**Abstract:** Seven typical PBDEs were measured in 50 ambient air samples collected from residential and roadside areas in Hanoi. The total concentrations of 7 PBDEs in the ambient air samples ranged from 23 to 287 pg/m$^3$ (mean: 81 pg/m$^3$). In the residential areas, the total levels of PBDEs were in the range of 23-73 pg/m$^3$ (mean: 42 pg/m$^3$). Meanwhile, the PBDE concentration measured in the air samples from traffic areas was significantly higher, ranging from 66-287 pg/m$^3$. Among PBDEs, BDE47 was found at the highest frequency in residential and traffic areas, accounting for 99% and 59%, respectively. The level of PBDEs in the air decreased at latitude. The PBDE concentrations in the air samples at the ground levels were 2 to 6 times higher than those at vertical from 24 to 111 m.

*Keywords:* PBDEs, Urban area, Air pollution, Passive air sampler, Spatial and vertical variability.

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## 1. Introduction

Brominated flame retardants (BFRs), particularly polybrominated diphenyl ethers (PBDEs), have been widely used in various consumer products to lower fire risk. Examples of these include decabromodiphenyl ethane (DBDPE), 1,2-bis-(2,4,6-tribromophenoxy)ethane (BTBPE), pentabromoethylbenzene (PBEB), and brominated phthalate esters [2, 9, 10, 14]. Because of their toxicity, persistence, bioaccumulation, and long-range transport, several of the most widely used BFRs, including tetra-to hepta-BDEs, deca-BDE, hexabromobiphenyl, and HBCDs, are listed as persistent organic pollutants (POPs) under the Stockholm Convention [26, 27, 28]. Sediment [1, 16], indoor dust [1, 21, 25], ambient air [25], biota [18, 19], soil [11, 17], and even humans [12, 24] have all been reported to have PBDEs in Vietnam. The processing of end-of-life vehicles (ELVs) [21], the disposal of municipal garbage [11], and the recycling of obsolete electronic material (e-waste) [1, 25] have all been implicated in previous studies as potential sources of PBDEs in this country. Moreover, studies have shown a strong link between ambient PBDE concentrations and urbanization [15, 20, 29]. However, research on the occurrence of PBDEs in the air environment in Vietnamese cities is still scarce. The levels of PBDEs in the air at e-waste recycling areas (620-720 pg/$m^3$), determined using passive sampling, were also higher compared with non-e-waste areas. According to Tue et al. (2013), the urban Hanoi region had atmospheric levels of PBDEs that were 5-12 times greater than those found in the suburban area [25]. The levels of PBDE found in residential dust collected from Hanoi were 1-2 orders of magnitude lower than those found in e-waste and ELV recycling facilities [1, 21, 25]. In addition, Vietnam lacks information regarding NBFR. High amounts of DBDPE were found in Hanoi household dust and e-waste landfills in the northern region of Vietnam, close to BDE209 [25]. The goal of this endeavor was to bridge the information gap about the degree of BFR pollution in the Vietnamese air.

## 2. Materials and methods

### *2.1. Chemicals and solvents*

In this study, 7 PBDEs target

standards, 01 internal standard (IS), and 01 surrogate standard (SS) were purchased from AccuStandard Inc. (New Haven, CT, USA). Sovents including DCM, *n*-hexane, isooctane, and toluene (GC-grade) were purchased from Merck KGaA (Darmstadt, Germany). Target, internal, and surrogate standards were dissolved in isooctane:toluene (80:20). Silica gel 60 (0.063-0.200 mm, Merck KGaA), activated charcoal (20-40 mesh particle size, Sigma-Aldrich), and anhydrous sodium sulfate (Sanchun Chemical Co., Gyeonggi-Do, Korea) were used for clean up steps.

### *2.2. Sample collection*

Polyurethane foam (PUF) disks [14.0 cm (diameter) x 1.35 cm (thick)] from Tisch Environmental, Cleves, OH, USA, were used for the passive air sampler (PAS) technique. The sampling protocol generally followed those reported in previous studies [4, 7, 22] with some modifications. Before sampling, the PUF disc was cleaned by sonication with acetone for 30 min and then dried at 60 °C in an oven for 4 h. The PUF disk was put into the PAS equipment which was hung about 1.5 m from the wall. Fifty ambient air samples were collected from 14 sites (Figure 1) in the Hanoi metropolitan area from May 2021 to December 2022. Two samples were collected in a period time of 20 or 21 days at one position. After collection, the PUFs were covered in aluminum foil, kept in an ice box, and transferred to the laboratory. The samples were analyzed immediately or stored at -20 °C in a freezer for no longer than 15 days.

### *2.3. Sample preparation*

The sample preparation process was carried out by earlier studies [4, 6, 22]. After being delivered to the lab, the PUF sample was rolled up and put in a thimble tube before being put into the Soxhlet extraction apparatus. Ten grams of $Na_2SO_4$ and 10 µL of the surrogate standard (2,2',3,3',4,4',5,5',6,6'-decachlorobiphenyl) solution (a concentration of 25 µg/mL) were added into the sample. The sample was extracted with 350 mL of a DCM:*n*-hexane (1/1; v/v) for 16 h using the Soxhlet method. The extracted solution was then concentrated to around 5 mL at 40 °C using a rotary evaporator (Buchi R-210 Rotavapor System, Marshall

Scientific). A column filled with 10 grams of silica gel and activated carbon (9/1; w/w) was used for the cleanup step. The target compounds were eluted using a 60 mL *n*-hexane/DCM (3/1; v/v) mixture. The eluted solution was evaporated to around 3 mL and transferred to a 10 mL glass tube. Then, the solution was concentrated to 0.1 mL under a gentle stream of nitrogen. The final sample was added 10 µL of the internal standard (4,4'-dibromooctafluo) solution (10 µg/mL). The sample was transferred to a GC vial to quantify PBDEs on the instrument.

### *2.4. Instrumental analysis*

An Agilent Technologies 8890B gas chromatograph (GC) interfaced with a 5977C mass spectrometer (MS) was used to analyze PBDEs. Separation of 7 PBDEs was achieved by an HP-5MS-UI capillary column (Agilent, Santa Clara, CA, USA; 5% diphenyl 95% dimethylpolysiloxane, 30 m x 0.25 mm i.d. x 0.25 µm film thickness). The chromatographic analysis condition was similar to that described earlier [6, 22] with slight modifications. In brief, the injector and ion source temperature were set at 300 °C and 230 °C, respectively. MS detector was set to the SIM (selected ion monitoring) mode with quantifier fragment (*m/z 1*) and comparison fragment (*m/z 2*). The oven column temperature: Initial 60 °C (hold 1 min), then increase 10 °C/min to 320 °C and hold for an additional 5 min to clean up the column. The carrier gas was helium with a purity above 99.99% and a 1.0 mL/min flow rate. The sample injection volume was 1 µL with the splitless mode.

### *2.5. QA/QC*

Surrogate standard recoveries, laboratory blanks, and sampling blanks were used in quality assurance and control (QA/QC). The preparation and analysis of the laboratory and sampling blanks followed the same protocol as the actual samples. PBDEs were not detected in all blank samples. The calibration curve was linear over a concentration range of 1-500 ng/mL (with a level of internal standard of 100 ng/mL) for individual PBDEs. The method detection limits (MDLs) were determined based on the lowest point in the calibration standard with a signal-to-noise ratio of 3 (S/N≈3), the average air volume collected (147 $m^3$), and the final concentrated solution volume (0,1 mL). Accordingly, the method quantification limits (MQL ≈ 3 * MDL) of PBDEs were from 8 to 29 $pg/m^3$. The recoveries of surrogate standards in blank and matrix samples ranged from 85% to 113% (PCB 209).

### *2.6. Statistical analysis*

Minitab 18® Statistical Software (Minitab LLC., State College, PA, USA) and Microsoft Excel (Microsoft Office 365) were used to perform the statistical analysis in this report. GIS software is used to depict PBDEs on the map. The level of statistical significance was set at $p < 0.05$. For concentrations below the MQLs, a value of one-half of the MQL was used in statistical analysis. The reported air flow rate (which was calibrated by the high-volume air sampler)-3.5 $m^3$/d [3, 6, 8, 25], 4 $m^3$/d [34], or 5 $m^3$/d [13]-multiplied by the period suspending the passive air sampler yielded the total air volume. Based on [3, 6] reported sampling period and sampling rate (3.5 $m^3$/d), the reported amounts of PBDEs in ambient air samples were calculated in this work.

## 3. Results and discussion

### *3.1. Spatial distribution of urban PBDEs*

Ambient air samples from Hanoi's metropolitan areas were collected between May 2021 (the wet season) and December 2022 (the dry season) for quantifying PBDEs. The total amounts of 7 PBDEs in ambient air samples varied from 23 to 287 $pg/m^3$ (mean: 81 $pg/m^3$) (Table 1). The table's data indicate that all samples have deficient PBDE levels, with BDE47 accounting for most samples (84%). Some traffic area samples also showed shallow BDE28, BDE99, and BDE 154 levels. Residential areas BDE47 account for 99% of the total PBDEs in Fig. 2, with an average of 42 $pg/m^3$ and a range of 23-73 $pg/m^3$, respectively. Traffic areas BDE47 account for 59% of the total PBDEs; the average is 154 $pg/m^3$, with 287 $pg/m^3$ being the greatest concentration and 66 $pg/m^3$ being the lowest. The overall concentration of PBDEs in the air in Hanoi is typically 81 $pg/m^3$, with fluctuations between 23 and 287 $pg/m^3$. The average total PBDEs in the traffic area are 3.7 times greater than those in the residential area.

BDE104, BDE153, and BDE183 were not found in any of the samples in residential areas. Every sample included BDE47. The detection frequency of BDE28 was comparatively high (17/49 samples). The detection frequency of the remaining drugs was modest, at 3/49 samples. This identifies the source of the commercial penta- and deca-BDE combination in the atmosphere. The range of the overall PBDE values was 23-73 pg/m$^3$. Of which the majority (99%) was BDE47, with the other isomers being essentially undetectable in all tests. The PBDE values (4.6-58 pg/m$^3$) found in our samples were greater than those in the 2008 Hanoi residential area samples [24]. This finding aligns with research indicating a high correlation between urbanization and ambient PBDE concentrations [15, 20, 29].

Total PBDE concentrations in traffic area samples ranged from 66-287 pg/m$^3$, with significant contributions from BDE28 and BDE47. BDE99 and BDE154 were present in a few samples. Our results differ from the study of [5], which found that PBDE concentrations in house dust samples higher road dust. This difference may be due to different standard isomer lists, sampling areas, and methods. Further research on PBDE emissions from vehicles is needed.

### *3.2. Vertical distribution of PBDEs*

The distributions of PBDEs in the air in Hanoi at vertical are reported for the first time in this paper (sample sites were collected from the ground, 8th, 15th, 27th, and 37th feet; each foot was 3 meters high). Samples collected at vertical elevations ranging from 24 to 111 meters had 7 PBDE values 2-6 times higher at ground level. There is no discernible difference in vertical between 45 and 111 meters (Figure 3). The poor volatilization of PBDEs in the air and their adsorption in dust particles, which makes their upward migration more complex, may cause the PBDEs to fall with altitude [3]. BDE28, BDE47, BDE99, and BDE154 contributed to PBDE compounds' abundance at ground level, while only BDE28 and BDE47 were found at higher elevations.

### *3.3. Seasonal distribution of urban PBDEs*

Table 1 displays the

mean/median (range) concentration ($pg/m^3$) of PBDEs in ambient air samples for each area's season. The results have tended to be similar to PBDEs (without BDE209) in central Europe [9]. The overall concentrations of PBDEs in the air during the dry season (mean/median: 47/45 and range: 25-84 $pg/m^3$) were substantially higher than those during the wet season (mean/median: 37/37 and range: 16-75 $pg/m^3$). The PBDE levels in the traffic areas during the dry season (mean/median: 153/132 and range: 73-287 $pg/m^3$), on the other hand, were comparable to those during the rainy season (mean/median: 155/137 and range: 66-278 $pg/m^3$). Overall, the study's findings were consistent with data (ranging from 5.45 to 272 $pg/m^3$) found in Hong Kong's metropolitan areas [30].

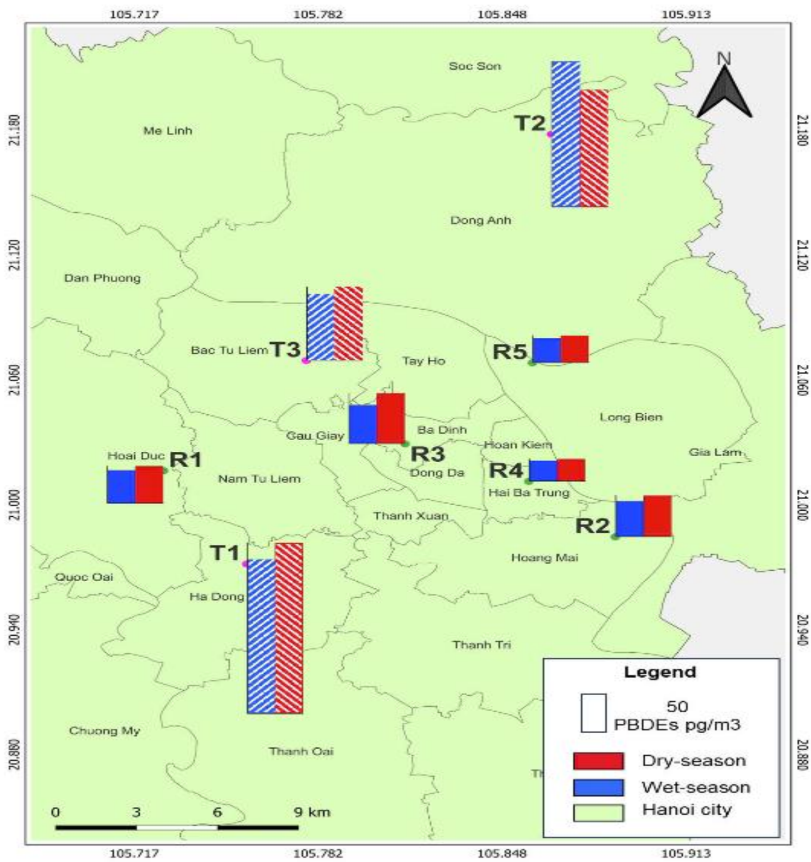


Figure 1. Levels of PBDEs in ambient air samples collected from the Hanoi urban areas

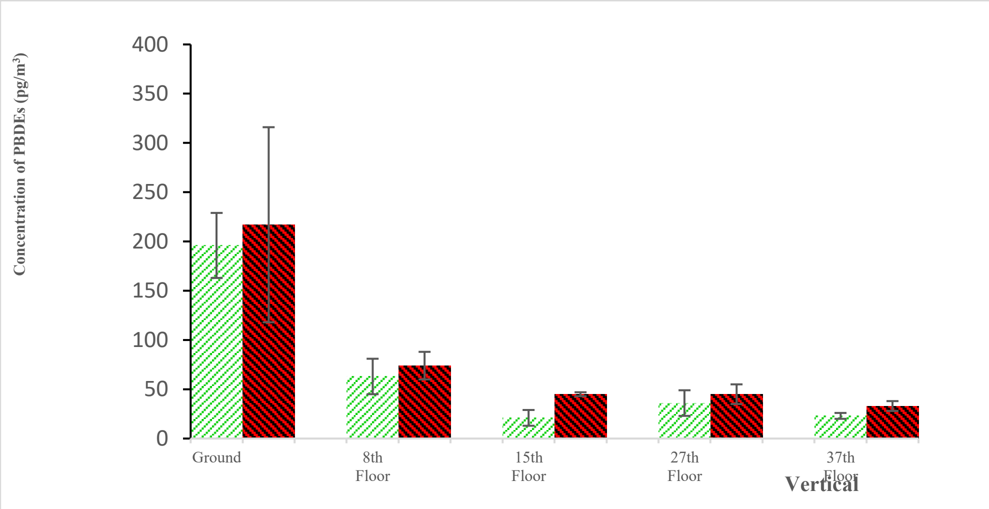


Figure 2. Vertical concentrations of PBDEs in ambient air samples collected from the Hanoi urban areas (2 samples for each season at one location)

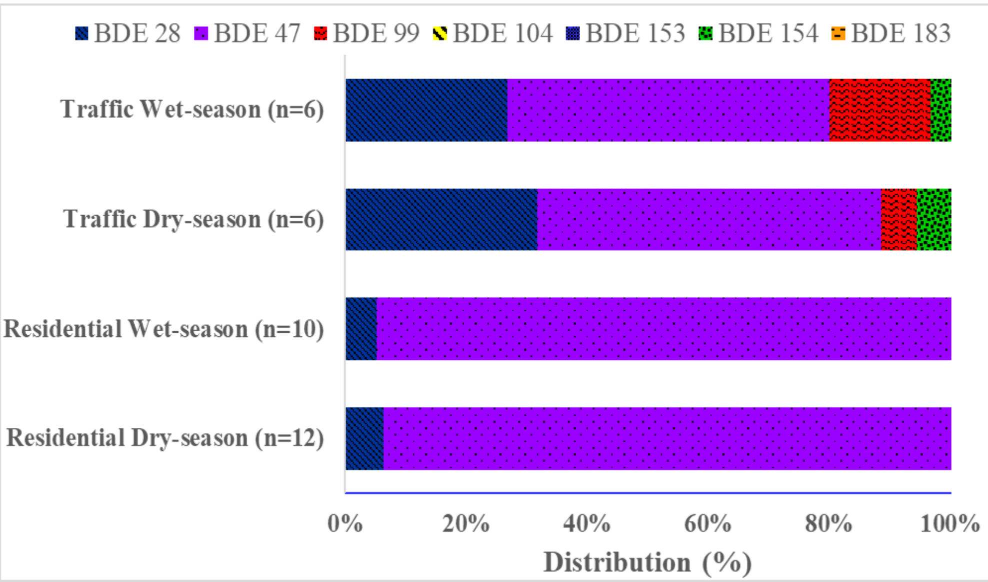


Figure 3. Seasonal distributions of PBDEs in ambient air samples collected from the Hanoi urban areas (values in parentheses refer to the number of samples analyzed)

Table 1. Mean/median (range) concentrations (pg/m3) of PBDEs in the ambient air samples

| Comp | Residential areas | | Traffic areas | |
|---|---|---|---|---|
| | *Dry season (n=20)* | *Wet season (n=18)* | *Dry season (n=6)* | *Wet season (n=6)* |
| BDE 28 | 3/n.d.(n.d.-24) | n.d./n.d.(n.d.-21) | 48/42(29-93) | 42/32(26-99) |
| BDE 47 | 44/44(25-73) | 35/36(16-54) | 87/84(44-133) | 82/72(40-124) |
| BDE 99 | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) | 9/n.d.(n.d.-54) | 26/n.d.(n.d.-123) |
| BDE 104 | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) |
| BDE 153 | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) |
| BDE 154 | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-36) | n.d./n.d.(n.d.-31) |
| BDE 183 | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) | n.d./n.d.(n.d.-n.d.) |
| **ΣPBDEs** | **47/45(25-84)** | **37/37(16-75)** | **153/132(73-287)** | **155/137(66-278)** |

*n.d.: no detection*

## 4. Conclusion

The first report on the vertical, seasonal, and spatial contributions of 7 PBDEs was investigated in the ambient air from the urban areas of Hanoi. The ambient air samples had total PBDE values ranging from 23 to 287 pg/m$^3$ (mean: 81 pg/m$^3$). BDE47 was found to be abundant among PBDEs. PBDE pollution levels in residential areas were approximately 3.7 times lower than those in traffic areas. Although moving higher does not significantly alter the PBDE levels in the air, those measured at ground level were higher than those from above. The dry season's PBDE concentrations were somewhat greater than the wet season's. The results of the study provide a useful database for monitoring PBDEs in Vietnam's survey networks and developing management.

## References

1. Anh Q.H., Keidai T., Tue M.N., Tri M.T., Minh B.T., Shin T. (2018). PBDEs and novel brominated flame retardants in road dust from northern Vietnam: Levels, congener profiles, emission sources and implications for human exposure. Chemosphere 197 (2018) 389-398.
2. Anh Q.H., Shin T., Thao T.D., Thai H.N., Khiet T.P., Hoa Q.T.N., Quynh P.T.L., Da N.L., Minh B.T., Tri M.T. (2019). Analysis and evaluation of contamination status of polycyclic aromatic hydrocarbons (PAHs) in settled house and road dust samples from Hanoi. VNU J. Sci. Nat. Sci. Technol. 35(4):63-71.
3. Anh Q.H., Watanable I., Tue M.N., Tuyen H.L., Viet H.P., Chi K.N., Minh B.T., Shin T. (2020). Polyurethane foam-based passive air sampling for simultaneous determination of POP- and PAH-related compounds: A case study in informal waste processing and urban areas, northern Vietnam. Chemosphere 247, 125991. https://doi. org/10.1016/j.chemosphere.2020.125991.
4. Anh Q.H., Tri M.T., Minh B.T., Shin T. (2021). Polybrominated diphenyl ethers in indoor and outdoor dust from Southeast Asia: An updated review on contamination status, human exposure, and future perspectives. Environ. Pollut. 272, 116012.
5. Anh Q.H., Shin T., Tuyen H.L., Tue M.N., Tu M.N., Nguyen T.T.T., Tu B.M. (2023). Polycyclic aromatic hydrocarbons in air and dust samples from Vietnamese end-of-life vehicle processing workshops: Contamination status, sources, and exposure risks. Bull. Environ. Contam. Toxicol 110(6):110. https://doi.org/10.1007/s00128-023-03757-x.
6. Cheng H., Deng Z., Chakraborty P., Liu D., Zhang R., Xu Y., Luo C., Zhang G., Li J. (2013). A comparison study of atmospheric polycyclic aromatic hydrocarbons in three Indian cities using PUF disk passive air samplers. Atmos. Environ. 73, 16-21.
7. Choi S.D., Kwon H.O., Lee Y.S., Park E.J., Oh JY. (2012). Improving the spatial resolution of atmospheric polycyclic aromatic hydrocarbons using passive air samplers in a multi-industrial city. J. Hazard. Mater. 241-242, 252-258. https://doi.org/10.1016/j.jhazmat.2012. 09.039.
8. De Boer J., de Boer K., Boon J.P. (2000). Polybrominated biphenyls and diphenylethers.

In: Paasivirta, J. (Ed.), The Handbook of Environmental Chemistry Vol. 3 Part K New Types of Persistent Halogenated Compounds. Springer, Berlin, Heidelberg, pp. 61-96.

9. De Wit C.A., Kierkegaard A., Ricklund N., Sellstrom U. (2010). Emerging brominated flame retardants in the environment. In: Eljarrat, E., Barcelo, D. (Eds.), The Handbook of Environmental Chemistry Vol. 16 Brominated Flame Retardants. Springer, Berlin, Heidelberg, pp. 241-286.
10. Eguchi A., Isobe T., Ramu K., Tue N.M., Sudaryanto A., Devanathan G., Viet P.H., Tana R.S., Takahashi S., Subramanian A., Tanabe S. (2013). Soil contamination by brominated flame retardants in open waste dumping sites in Asian developing countries. Chemosphere 90, 2365-2371.
11. Eguchi A., Nomiyama K., Tue N.M., Trang P.T.K., Viet P.H., Takahashi S., Tanabe S. (2015). Residue profiles of organohalogen compounds in human serum from ewaste recycling sites in North Vietnam: association with thyroid hormone levels. Environ. Res. 137, 440-449.
12. Harner T, Su K, Genualdi S, Karpowicz J, Ahrens L, Mihele C, Schuster J, Charland JP, Narayan J. (2013). Calibration and application of PUF disk passive air samplers for tracking polycyclic aromatic compounds (PACs). Atmos. Environ. 75:123-128. https://doi.org/ 10.1016/j.atmosenv.2013.04.012
13. Law R.J., Covaci A., Harrad S., Herzke D., Abdallah M.A.E., Fernie K., Toms L.M.L., Takigami H. (2014). Levels and trends of PBDEs and HBCDs in the global environment: status at the end of 2012. Environ. Int. 65, 147-158.
14. Li K., Fu S., Yang Z.Z., Xu X.B. (2008). Composition, distribution and characterization of polybrominated diphenyl ethers (PBDEs) in the soil in Taiyuan, China. Bull. Environ. Contam. Toxicol. 81, 588-593.
15. Mai P.T.N., Thuong N.V., Tham T.T., Hoang N.K., Anh H.Q., Tri T.M., Hung L.S., Nhung D.T., Nam V.D., Hue N.T.M., Huong N.T.A., Anh D.H., Minh N.H., Minh T.B. (2015). Distribution, accumulation profile, and risk assessment of polybrominated diphenyl ethers in sediment from lake and river systems in Hanoi Metropolitan Area, Vietnam. Environ. Sci. Pollut. Res. https://doi.org/ 10.1007/s11356-015-5235-7.
16. Matsukami H., Tue N.M., Suzuki G., Someya M., Tuyen L.H., Viet P.H., Takahashi S., Tanabe S., Takigami H.

(2015). Flame retardant emission from ewaste recycling operation in northern Vietnam: environmental occurrence of emerging organophosphorus esters used as alternatives for PBDEs. Sci. Total Environ. 514, 492-499.

17. Minh N.H., Minh T.B., Kajiwara N., Kunisue T., Iwata H., Viet P.H., Tu N.P.C., Tuyen B.C., Tanabe S. (2006). Contamination by polybrominated ethers and persistent organochlorines in catfish and feed from Mekong River Delta, Vietnam. Environ. Toxicol. Chem. 25, 2700-2709.
18. Ramu K., Kajiwara N., Sudaryanto A., Isobe T., Takahashi S., Subramanian A., Ueno D., Zheng G.J., Lam P.K.S., Takada H., Zakaria M.H., Viet P.H., Prudente M., Tana T.S., Tanabe S. (2007). Asian Mussel Watch Program: contamination status of polybrominated diphenyl ethers and organochlorines in coastal waters of Asian Countries. Environ. Sci. Technol. 41, 4580-4586.
19. Stapleton H.M., Dodder N.G., Offenberg J.H., Schantz M.M., Wise S.A. (2005). Polybrominated diphenyl ethers in house dust and clothes dryer lint. Environ. Sci. Technol. 39, 925-931.
20. Takahashi S., Tue N.M., Takayanagi C., Tuyen L.H., Suzuki G., Matsukami H., Viet P.H., Kunisue T., Tanabe S. (2017). PCBs, PBDEs and dioxin-related compounds in floor dust from an informal end-of-life vehicle recycling site in northern Vietnam: contamination levels and implications for human exposure. J. Mater. Cycles Waste Manag. 19, 1333-1341.
21. Thang Q.P., Kim S.J., Lee S.J., Kim C.H., Lim H.J., Lee S.B., Kim J.Y., Vuong Q.T., Choi S.D. (2020). Monitoring of polycyclic aromatic hydrocarbons using passive air samplers in Seoul, South Korea: Spatial distribution, seasonal variation, and source identification. Atmos. Environ. 229, 117460. https://doi.org/10.1016/j. atmosenv.2020.117460.
22. Tuduri L., Harner T., Hung H. (2006). Polyurethane foam (PUF) disks passive air samplers: Wind effect on sampling rates. Environ Pollut 144:377-383. https://doi.org/10.1016/j.envpol.2005.12. 047.
23. Tue N.M., Sudaryanto A., Minh T.B., Isobe T., Takahashi S., Viet P.H., Tanabe S. (2010). Accumulation of polychlorinated biphenyls and brominated flame retardants in breast milk from women living in Vietnamese e-waste recycling sites. Sci. Total Environ. 408, 2155-2162.
24. Tue N.M., Takahashi S.,

Suzuki G., Isobe T., Viet P.H., Kobara Y., Seike N., Zhang G., Sudaryanto A., Tanabe S. (2013). Contamination of indoor dust and air by polychlorinated biphenyls and brominated flame retardants and relevance of non- dietary exposure in Vietnamese informal e-waste recycling sites. Environ. Int. 51, 160-167.

25. United Nations Environment Programme (UNEP), 2013. UNEP/POPS/COP.6/SC-6/13. http://chm.pops.int/portals/0/download.aspx?d¼UNEP-POPS-COP.6-SC-6-13. English.pdf. (Accessed 25 September 2024).

26. United Nations Environment Programme (UNEP) (2017a). Guidance for the Inventory of Polybrominated Diphenyl Ethers (PBDEs) Listed under the Stockholm Convention on Persistent Organic Pollutants. http://chm.pops.int/Implementation/NationalImplementationPlans/Guidance/GuidancefortheinventoryofPBDEs/tabid/3171/Default.aspx. (Accessed 26 September 2024).

27. United Nations Environment Programme (UNEP) (2017b). UNEP/POPS/COP.8/13. http://chm.pops.int/TheConvention/ConferenceoftheParties/Meetings/COP8/tabid/5309/Default.aspx. (Accessed 25 September 2024).

28. Wu M.H., Pei J.C., Zheng M., Tang L., Bao Y.Y., Xu B.T., Sun R., Sun Y.F., Xu G., Lei J.Q. (2015). Polybrominated diphenyl ethers (PBDEs) in soil and outdoor dust from a multi-functional area of Shanghai: levels, compositional profiles and interrelationships. Chemosphere 118, 87-95.

29. Wenjing D., Zheng S.J., Bi H.X., Fu M.J., Wong H.M. (2007). Distribution of PBDEs in air particles from an electronic waste recycling site compared with Guangzhou and Hong Kong, South China. Environ. Int. 33(8), 1063-1069.

# Analysis and Proposed Solutions for Dust Reduction in Underground Mining at Quang Ninh Coalmine

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**Abstract:** Coal is one of the main energy sources in Vietnam, serving as an important raw material for many other production sectors. Currently, most coal mines have shifted to underground mining methods. However, the working conditions in underground mines are harsh, with hot and humid environments, and toxic gases, particularly mine dust, which increases the risk of occupational diseases and affects the health of miners. This paper employs field surveys, data statistics, and analysis of the impact of dust on workers' health, and proposes reasonable dust control methods for underground coal mines in the Quang Ninh region. The research results show that dust is generated in all operational stages such as tunneling, transportation, and mining. Dust concentrations in basic operations like extraction, tunneling, and transportation of coal and rock exceed the maximum allowable concentrations in mine air by 4 to 10 times. Workers who have been in underground mines for 5 years have a 15% risk of developing pneumoconiosis, which increases to 22% after 10 years and up to 35% after 11 years of dust exposure. The paper proposes using a high-

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pressure mist spray circulation method to suppress dust at dust-generating locations in underground mines. The effectiveness of this method has reduced dust concentrations by 80%, ensuring compliance with the maximum allowable dust concentration according to national standards.

*Keywords:* Coal, underground mining, dust, toxic, pneumoconiosis

## 1. Introduction

Vietnam is a developing economy in which the extraction and processing of resources such as coal and other minerals remain a key driver and significant source of revenue for the country's economic growth. The mining industry in general, and underground mining in particular, is one of the most physically demanding sectors, with inherent risks to occupational safety and hygiene. These dangers are evidenced by numerous serious accidents and the high incidence of occupational diseases. The hazards in underground mining of solid minerals stem from various causes, including methane explosions, coal dust explosions, explosions of sulfur-containing ore dust, flooding and water surges, ground collapses in tunnels, coal seam collapses, and mine fires [1].

The working conditions in underground mines are extremely harsh, with heavy labor, high humidity, and exposure to toxic gases, especially mine dust, which significantly increases the risk of occupational diseases and affects the health of mine workers. According to data from the Coal Industry Medical Center, as of now, more than 2,000 of the 118,000 workers in the mining industry have been diagnosed with lung diseases (accounting for 14% of the 18 recognized occupational diseases) after health screenings [2]. Among these, the rate of pneumoconiosis—a progressive and irreversible lung disease—stands out, particularly in the coal mining sector, where it affects 3-14% of miners, and up to 70% of underground workers diagnosed with the disease. Studies show that miners working underground for five years or more face a 14% risk of developing pneumoconiosis. This risk increases to 21% after nine years, and up to 35% after 10-14 years of exposure to dust [2]. Prolonged exposure not only heightens the risk of pneumoconiosis but also makes miners more susceptible to primary lung cancer, laryngeal cancer, and nasopharyngeal cancer [3,4].

Mine dust is a leading cause of occupational diseases, such as pneumoconiosis, bronchial asthma, and respiratory, eye, ear, nose, and throat conditions, all of which affect workers' health and the quality of life in the community. To mitigate environmental pollution from mine dust, the only solution is to implement comprehensive dust control measures, reducing dust concentrations to permissible levels to protect the long-term health of mine workers. This is essential to prevent the burden on society from the loss of skilled labor and the healthcare costs associated with retired miners.

With these above-mentioned facts, there is a need for numerous studies on the "Impact and Mitigation of Dust Exposure on Workers in Underground Coal Mines in Quang Ninh Province" to meet the requirements for sustainable development in the Quang Ninh coal mining region. These efforts aim to minimize occupational diseases related to pneumoconiosis, ensure the health of workers, and improve the quality of life in the community.

## 2. Characteristics of Geological and Technical Conditions of the Quang Ninh Coal Region

The coal in the Quang Ninh region is primarily anthracite and semi-anthracite. The coal reserves are mainly concentrated in the area from Pha Lai to Ke Bao, covering approximately 300 $km^2$, with a calculated reserve of 3.222 billion tons as of January 1, 1995. A significant portion of the coal, about 80% of the total reserve, is mined using underground mining methods.

The anthracite and semi-anthracite coal from the Quang Ninh region has medium ash content, high calorific value, and low sulfur content. The common rocks found in the mining area include carbonaceous shale, claystone, siltstone, sandstone, and conglomerate, which vary from coarse to fine-grained and range in color from light gray to dark gray. The main components of these rocks are quartz sand, with silicic clay as the cementing material. The rocks are blocky in structure, with thick to medium-thin layers and numerous fractures. The chemical composition and SiO2 content of the coal and ash from the Quang Ninh coal region are shown in Tables 1.1 and 1.2. [5]

Table 1.1. Chemical Composition of $SiO_2$ in Coal and Coal Ash from the Quang Ninh Region.

| **Mine name** | **Analysed content %** | | |
|---|---|---|---|
| | Min | Max | Average |
| Nam Mau (coal dust) | 8,84 | 83,24 | 42,82 |
| Khe Cham (coal ash) | 31,83 | 59,49 | 45,66 |
| Thong Nhat (coal dust) | 1,88 | 68,28 | 35,08 |
| Duong Huy (tro ash) | 1,58 | 41,16 | 17,38 |
| Mao Khe (coal dust) | 15,2 | 39,2 | 27,2 |
| Vang Danh (coal dust) | 11,2 | 31,2 | 21,2 |

Table 1.2. $SiO_2$ Content in Lithology by Stratigraphy in the Quang Ninh Region

| **No.** | **Area** | **Sandstone** | **Siltstone** | **Claystone** | **Carbonaceous Shale** | **Coal** |
|---|---|---|---|---|---|---|
| 1 | Hon Gai - Cam Pha | 51,56 | 36,04 | 4,14 | 0,73 | 3,05 |
| 2 | Trang Bach | 47,53 | 24,35 | 12,07 | 0,13 | 3,72 |
| 3 | Mao Khe | 46,50 | 27,25 | 12,07 | 0,77 | 4,66 |

From the data in the tables, we can see that the free silica content (a significant factor in causing pneumoconiosis) in Quang Ninh coal varies between 1.58% and 83.24%. In the surrounding rocks, the SiO2 content is also high, ranging from 0.13% to 51.56%. Most of the coal reserves above the water level in the Quang Ninh coal region have already been extracted. Many mines have been or are currently mining deep below -300 meters relative to sea level. To access the deeper reserves, inclined or vertical shaft mining methods are widely applied at various mines [6].

Underground mining operations in the Quang Ninh region primarily use drilling and blasting techniques, with a relatively low degree of mechanization. In recent years, some underground mines have invested in mechanized tunneling equipment. Initial results show that certain production lines are well-suited to the geological conditions and mining operations, improving productivity and reducing labor requirements.

The technologies applied in traditional longwall mining in Vietnam include manual drilling and blasting, semi-mechanized mining, and fully mechanized mining.

Currently, the drilling and blasting method is still the most commonly used technology in longwall coal mining. In this method, coalface extraction is performed by drilling and loading explosives on the coalface. Roof support consists of single hydraulic props or frames of composite supports.

Figure 1-1. Drilling and Blasting Technology and Mechanical Extraction in Longwall Coal Mining

The manual drilling and blasting method has the disadvantage that all operations rely on human labor. Heavy work, exposure to toxic dust and gases, and time-consuming tasks like roof support and mine pressure control make safety levels lower. This results in low production and efficiency, with high risks of occupational diseases and accidents in longwall mining.

To increase mechanization in mining, several mechanized mining technologies have been adopted. In 2005, the first fully mechanized longwall using a shearer was introduced at Khe Cham mine with a production capacity of 400,000 tons/year. By 2012, more than 10 fully mechanized longwalls had been implemented, including high-capacity longwalls such as Ha Lam mine, which reached 1.2 million tons/year [7].

**3. Regulations on the Maximum Permissible Dust Concentration in Underground Mine Air in**

**Vietnam**

Dust in the work environment is generated from production processes in the mines. It consists of small particles that remain airborne for a long time as suspended dust, settling dust, and aerosols like vapors, mists, and smoke formed by the breakdown of materials due to natural forces or mining activities.

The work environment plays a crucial role in workers' health and productivity. Depending on the industry, the work environment requirements vary. Based on work environments and workers' health, scientists and regulators have developed standards to ensure a safe work environment for each type of job and industry. One of the most hazardous industries for workers' health is underground coal mining, where occupational diseases like pneumoconiosis are common and increasing.

According to the VietNam technical standard on safety in underground coal mining (QCVN 01:2011/BCT), the permissible dust concentration in working areas is shown in Table 1.3 [8]

Table 1.3. Permissible Dust Concentration in Underground Work Areas

| Dust Characteristics | Free Silica Content in Dust (%) | Total Dust Concentration Limit (mg/m³) |
|---|---|---|
| Rock and overburden | 10 to 70 | 2 |
| Coal and overburden | 5 to 10 | 4 |
| Anthracite | Up to 5 | 6 |
| Stone coal dust | Up to 5 | 10 |

## 4. Dust Analysis by Technology at Several Underground Mines in the Quang Ninh Region

Various activities in underground mines contribute to air pollution, such as drilling, blasting, loading waste rock and coal, transporting waste rock from tunnel excavation to dump sites, and transporting coal using trolleys or conveyors. Dust is generated in nearly every operation and heavily pollutes the underground air. Measuring dust concentrations during the workday is complex, as air dust levels depend on work shifts, and dust generation is unstable over time. To evaluate dust pollution levels according to standards, dust concentrations must be measured for each production process within a shift. To prevent pneumoconiosis (silicosis), dust concentrations must be measured over three consecutive shifts, with the average dust concentration used to develop appropriate dust control solutions. Therefore, measuring dust at specific points during each production process in a shift is suitable for the underground coal mining conditions in the Quang Ninh region.

To determine dust levels in underground coal mining in Quang Ninh, the research team used the U.S.-made Hazdust Laser Model 770-1100B for total dust and the Cano Max Model 3443 for fine dust, as shown in Figure 1-2. Measurements were taken at two mechanized longwalls: Longwall 11 at Ha Lam coal mine and Longwall 7 at Nam Mau coal mine. The measurement locations were in the longwall, 10 meters from the ventilation roadway, and 15 meters from the longwall entrance. Measurements were taken during different production activities in the longwalls.


Figure 1-2. Total Dust and Fine Dust Measurement Devices

The actual dust results obtained in the longwall faces are shown in table 1.4 and 1.5 below:

Table 1.4. Dust concentration measurements in the mechanized longwall face of Seam 11, Ha Lam coal mine

| No. | Production stages during the shift | Fine dust concentration (mg/m3) | Total dust concentration (mg/m3) | Correlation coefficient K |
|---|---|---|---|---|
| 1 | Transportation, face improvement | 1,564 | 2,937 | 1,986 |
| 2 | Coal cutting | 2,543 | 7,067 | 2,728 |
| 3 | Coal transportation, support movement | 1,702 | 1,63 | 0,957 |
| 4 | Face cutting | 2,157 | 4,55 | 2,021 |
| 5 | Coal transportation, shield movement | 1,403 | 1.567 | 1,136 |
| | | | Kave | 1,765 |

Table 1.5. Dust concentration measurements in the blast-hole longwall face of Seam 7, Nam Mau coal mine

| No. | Production stages during the shift | Fine dust concentration (mg/m3) | Total dust concentration (mg/m3) | Correlation coefficient K |
|---|---|---|---|---|
| 1 | Longwall support | 1,304 | 2,75 | 2,109 |
| 2 | Blast-hole drilling | 1,412 | 2,93 | 2,075 |
| 3 | Explosive charging | 1,756 | 8,65 | 4,926 |
| 4 | Coal load/ transport | 1,322 | 4,61 | 3,487 |
| 5 | Support movement, wall rock destruction | 1,359 | 2,93 | 2,156 |
| | | | Kave | 2,512 |

From the actual monitoring results at several longwall coal mining faces in the Quang Ninh region, it is clear that all production activities in the longwall face generate dust. The process of cutting coal using coal-cutting machines or drilling and blasting is always a major source of dust. Additionally, activities such as loading and transporting coal using scrapers, moving supports, and destroying wall rocks in the longwall face also contribute to significant dust generation.

In mechanized longwall faces, fine dust concentrations range from 1.215 to 3.03 mg/m³, with the coal cutting process always having the highest fine dust concentration, ranging from 2.01 to 3.03 mg/m³. In other processes (coal transport, face correction, pushing shields, support movement), fine dust concentrations are typically lower, ranging from 1.215 to 1.783 mg/m³. Total dust concentrations in the longwall face range from 1.42 to 9.10 mg/m³, with the highest levels of dust occurring in the coal-cutting process, ranging from 3.89 to 9.10 mg/m³. Other production stages generate lower dust levels, with total dust concentrations in the air ranging from 1.42 to 3.71 mg/m³.

In longwall faces using drilling and blasting, fine dust concentrations range from 1.112 to 1.826 mg/m³, with blasting and coal transport typically producing the highest concentrations, ranging from 1.429 to 1.826 mg/m³. Other stages generally generate lower fine dust levels. Total dust concentrations in the air range from 1.85 to 8.65 mg/m³. Similar to mechanized longwall faces, the blasting process in blast-hole longwalls produces the highest dust concentrations, ranging from 5.64 to 8.65 mg/m³.

Comparing the observed results of the various production stages in underground coal mining operations with the National Technical Regulation on Occupational Safety in Underground Coal Mining (QCVN 01:2011/BCT), it can be seen that they generally comply with the allowable standards. However, there are times when the total dust levels generated in the longwall face exceed the permissible limits. Stages that typically exceed the allowable dust levels are usually those involving drilling and blasting or coal-cutting with a continuous miner. Therefore, it is necessary to implement technical solutions to prevent dust generation during production processes in underground coal mining.

## 5. Proposed Solutions for Dust Control in Underground Coal Mining

Currently, in underground coal mines, dust control methods include regular water spraying, high-pressure water spraying, and ventilation [9,10]. These are basic dust control methods widely applied in mines, not only to reduce dust but also to dilute methane content, other harmful gases, and improve the working environment for miners. However, due to the characteristics of each stage of production, the intensity of dust generation and its spread vary by location. The biggest challenge in applying dust control methods is the size of the cross-section of the tunnel, wind speed, coal quality, and the mechanical properties of the surrounding rock. Therefore, the research team proposes to use a combined dust control method for each stage of production to improve efficiency. The combined method includes ventilation along with high-pressure mist spraying, regular-pressure mist spraying, and using water hole plug for blasting.

### *5.1 Dust Control for Mechanized Longwall Mining*

In underground coal mining, the longwall mining face is the area where the most dust is generated. Particularly in fully mechanized longwall mining, the process of cutting coal using mining machinery generates a large amount of dust, most of which is fine dust. This dust not only pollutes the air but also causes pneumoconiosis for workers in underground mines.

The method of coal cutting in the longwall has a significant impact on the distribution of dust generated during the cutting process. When the cutting machine moves in the same direction as the wind or against it, the distribution and movement of the dust stream differ. When the cutting machine moves in the same direction as the wind, the dust impact on the machine operator and other workers behind the machine is reduced. Conversely, when the cutting machine moves against the wind, workers are more exposed to dust

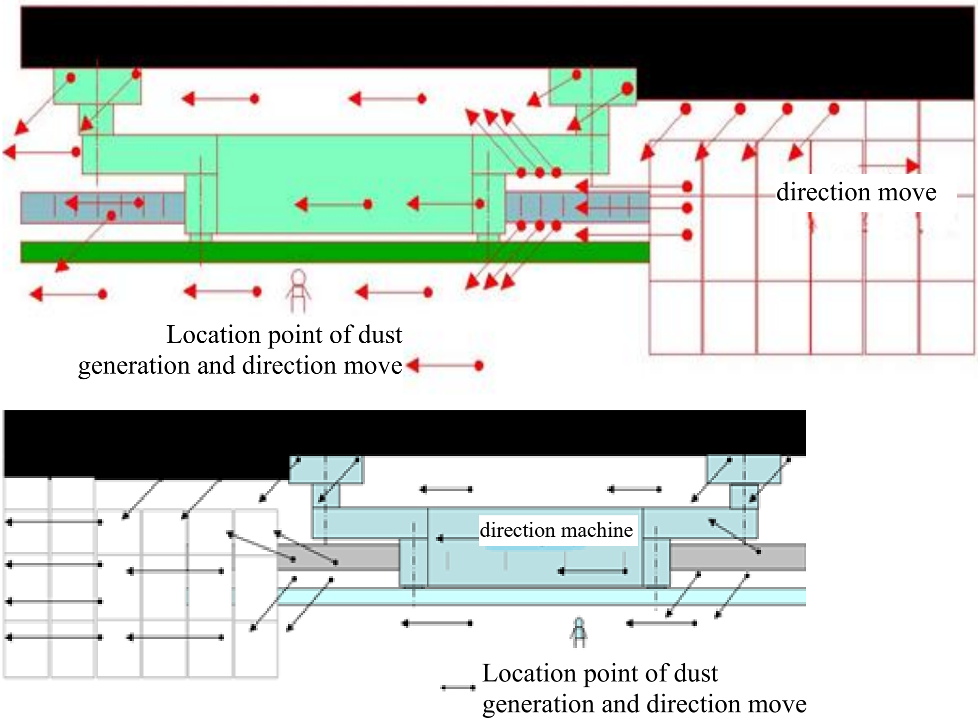


Figure 1-3. Dust stream direction when the cutting machine moves in the opposite direction to the wind or with the wind.

Currently, high-pressure mist spraying from devices installed on the cutting drum of the mining machine and the support structures is the main dust control method for mechanized longwall mining globally. However, traditional fixed mist spray nozzles on the cutting drum hinder airflow in the longwall, causing the mist and dust to move into the workers' paths, reducing the dust suppression efficiency.

To address these drawbacks, the research team proposes modifying the spray nozzle direction to align with the airflow by relocating the mist spraying system from the cutting drum to the machine arm and adjusting the nozzles to spray in the same direction as the wind. However, it is crucial to ensure that the spray effectively covers the dust generated by the cutting drum. The layout of the mist spray dust suppression system for the cutting machine before and after improvements is shown in Figure 1-4.

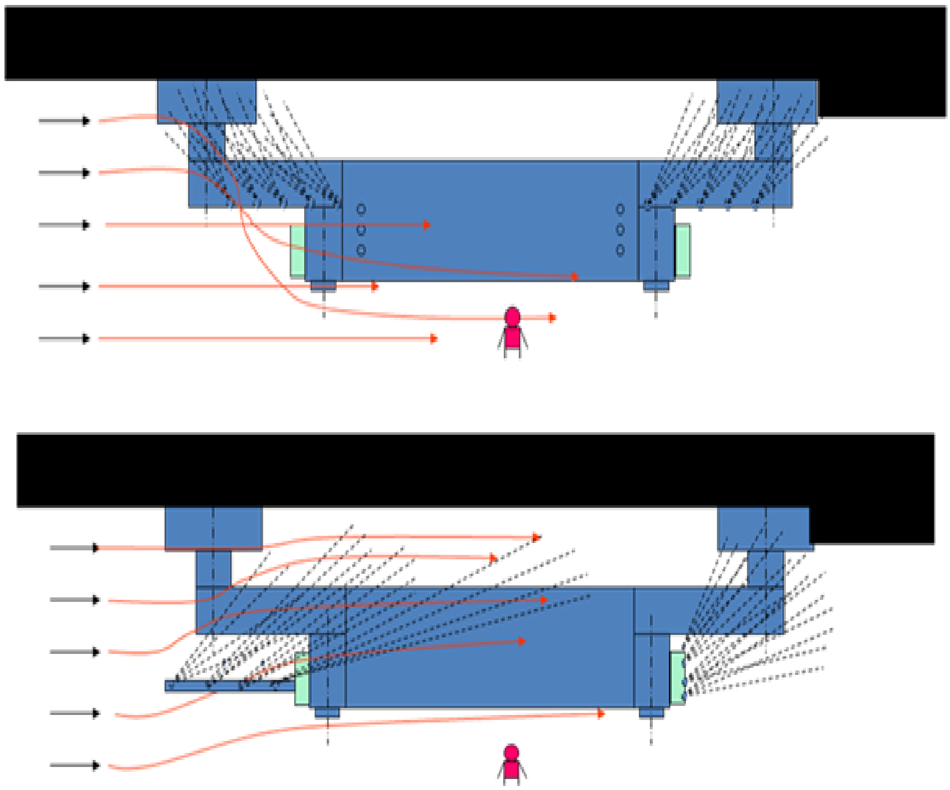

Figure 1-4. Mist spraying layout before and after improvements.

After making these adjustments, the nozzles spray in the same direction as the wind, improving airflow in the longwall. The wind pressure helps the mist cover a wider area, and the dust moves along the coal face rather than into workers' paths, significantly improving the working environment.

### *5.2. Dust Control During Tunneling:*

Using ventilation to control dust involves directing airflow into the tunnel face with an optimal wind speed of 0.5-0.7 m/s. The ventilation solution ensures that the distance from the end of the ventilation duct to the tunnel face is maintained at 8 meters, with airflow speed at 0.5 m/s.

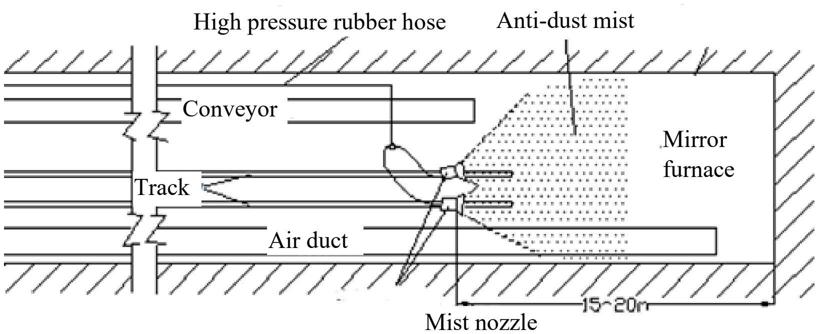


Figure 1-5. Ejector system layout for dust control during tunneling

High-pressure circulating mist spraying can also be used to suppress dust during tunneling with a mobile ejector dust suppression system.

### *5.3. Dust Control for Blasting in Longwall Mining*

Ventilation can be used to control dust in all stages, with airflow rates in longwall mining set at 0.9-2 m/s, optimized at 1.6 m/s for long longwalls and 0.5-0.7 m/s for sloping longwalls. Blasting holes are loaded with water bags instead of clay, which are tightly packed with clay afterward.

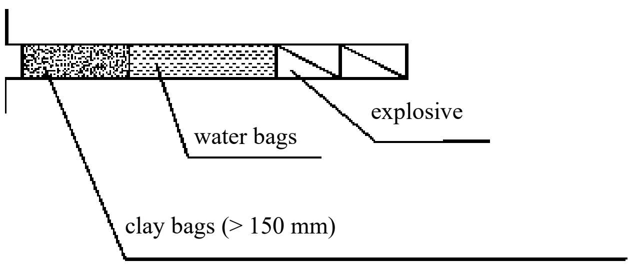


Figure 1-6. Loading blasting holes with water bags

The water bags are made from polyethylene tubes, 1-3 mm smaller in diameter than the blasting holes, and are sealed with one-way valves.

## 6. Efficiency of the Proposed Solution

Based on the practical experience from underground coal mines in the Quang Ninh region and research results from both domestic and international sources, integrated dust suppression is the most commonly used and effective method. This is the most reasonable and feasible approach as the dust control system is simple, flexible, cost-effective in terms of investment, and easy to operate, with the following advantages:

It minimizes the amount of water used. The high-pressure mist spraying system reduces the required water volume by 2 to 3 times compared to regular water spraying, with dust suppression efficiency reaching 80% or more. Using this high-pressure mist system also reduces the ambient temperature by 1 to 1.5°C, helping to improve the microclimate conditions in the area [5,7].

The integration of two dust control methods within the high-pressure mist system involves mist spraying and other dust suppression techniques applied to different production stages of the mine. Dust particles are captured immediately within the range of water mist jets from the spray nozzles. This method does not wet the mine roadways or coal conveyors, preventing production stoppages or issues with workers moving through the tunnels. It also prevents the spread of dust by wind throughout the tunnels. The system is simple in structure, easy to use, does not cause congestion in the tunnels, and operates without noise.

## 7. Conclusion

1) Dust is generated in all stages of underground coal mining. The total amount of dust generated is elatively large, especially during coal cutting and blasting. Dust adversely affects the air quality in the mine, the workers' health, and reduces labor productivity.

2) The analysis of dust concentrations in Quang Ninh coal mines shows that dust levels typically fluctuate between 3-4 $mg/m^3$, sometimes exceeding 7-8 $mg/m^3$. Although these levels are generally below the permissible limit of 10 $mg/m^3$ set by QCVN 01:2011/BCT, dust levels occasionally exceed the limit during blasting or coal cutting operations.

3) To ensure effective dust control, a combination of dust suppression methods must be applied, most of which involve water in various forms. High-pressure circulating mist spraying can achieve up to 80% dust suppression efficiency while also reducing the area's temperature by 1-1.5°C, improving the climate conditions in this region. This method can be implemented in

several coal mines in the Quang Ninh region

## References

1. Nguyen The He (2010), Research on Developing a Method to Assess Workers' Respiratory Dust Exposure Levels in Underground Coal Mining Using Personal Dust Monitoring Devices and Proposing Preventive Measures, Department of Science and Technology of Quang Ninh province, (Vietnamese).
2. Coal Industry of Medical Center - Vinacomin (2014), Pneumoconiosis statistics book of the Labor Health Center - 2011, 2012, 2013, 2014, Ha Noi, (Vietnamese).
3. Center for Occupational Preventive Medicine, Department of Health of Quang Ninh province ( 2010), Training Document on Occupational Disease Prevention, Quang Ninh, (Vietnamese).
4. Report on the results of implementing labor environment monitoring at Nam Mau Coal Company – TKV, 2018, Center for Science and Technology Services for Health and Environment, Institute of Occupational Health and Environment - Ministry of Health.
5. Le Van Manh. Study on the impact and measures to minimize the impact of dust on workers in underground coal mines in Quang Ninh province; PhD thesis in engineering, 2018;
6. Nguyen Canh Nam; Overview of global coal reserves and consumption. Vietnam Energy Magazine, 11/2017.
7. Bui Manh Tung; Summary report of national science and technology topics, 2018. Research on scientific basis and practice to develop regulations on determining maximum allowable limits of dust in underground coal mine air; Code: 21.BS.18/HĐ-KHCN/NSCL.
8. Ministry of Industry and Trade of Vietnam (2011), National Technical Regulation on Safety in Underground Coal Mining. QCVN01:2011/BCT- 2011, HaNoi.
9. Tran Xuan Ha, Đang Vu Chi (2012), Occupational safety and hygiene in underground mining, Science and Technology Publishing House, Hanoi.
10. Le Van Thao (1989), Research on dust control solutions using water energy when digging tunnels with roadheaders for Vietnamese conditions, (Russian). PhD thesis in engineering MGI, Maxcova
11. Present Status of Respirable Dust Control Technology In Japanese Miles – Proceedings of the Internationl Mining Tech. 98 Symposium Chongqing/China/ 14-16 October 1998.
12. By Fred N. Kissell, Ph. D; Handbook for Dust Control in Mining.National Institute for Occupational Safety and Health Pittsburgh Research Laboratory Pittsburgh, No. 2003-147.

# Mapping the spatial (geological) distribution of Aedes mosquitoes and dengue cases in Hanoi, period 2018 - 2020

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**Abstract:** Mapping of the distribution of Aedes adult, larva and dengue fever (DF) cases at 583 sites (communes/wards) in 30 districts of Hanoi city from January 2018 to December 2020. The results show that, in 2018, 174 sites (commune/ward) had no cases, 393 sites had 1-50 cases, 13 sites had 51-100 cases and only 3 sites had more than 100 cases. In 2019, 78 sites had no cases, 426 sites had 1-50 cases, 59 sites had 51-100 cases and 203 sites had more than 100 cases. In 2020, 111 sites had no cases, 452 sites had 1-50 cases, 15 sites had 51-100 cases and 5 sites had more than 100 cases. The results of the survey on Aedes mosquito and larva index showed that: at all survey sites, the presence of Aedes mosquitoes was detected. Sites with indicators of mosquitoes, larva species *Aedes aegypti* is higher than that of *Aedes albopictus*, the majority had a high number of dengue cases.

*Keywords*: Dengue hemorrhagic fever, *Aedes albopictus*, *Aedes aegypti*

## 1. Introduction

Dengue fever is a vector-borne disease with an increasing number of cases and a widening area of endemicity in recent years. Meteorological factors influence dengue transmission. Dengue and severe dengue is one of the most serious and significant tropical

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diseases worldwide [8]. The known causes of the disease are the four serotypes of Dengue virus (DENV-1, DENV-2, DENV-3, DENV-4) [1]. Dengue is found in tropical and sub-tropical climates worldwide, mostly in urban and semi-urban areas. The disease is now endemic in more than 100 countries in the WHO Regions of Africa, the Americas, the Eastern Mediterranean, South-East Asia and the Western Pacific. The Americas, South-East Asia and Western Pacific regions are the most seriously affected, with Asia representing around 70% of the global disease burden. Dengue is spreading to new areas in Europe, the Eastern Mediterranean and South America in 2023. A surge in local transmission of dengue by *Ae. albopictus* (tiger mosquito) has been also seen in Europe this year [10]. The incidence of dengue has grown dramatically around the world in recent decades, with number of cases reported to WHO increasing from 505,430 in 2000 to 5.2 million in 2019 [9, 10]. Recently, the highest number of DF cases was recorded in 2023, affecting over 80 countries in all WHO regions. Since the beginning of 2023 ongoing transmission, combined with an unexpected spike in dengue cases, resulted in a historic high number of over 6.5 million cases and more than 7,300 dengue-related deaths reported. The WHO Region of the Americas reported 4.5 million cases, with 2,300 deaths. Countries with a high number of cases reported in Asia were: Malaysia (111,400), Thailand (150,000), Bangladesh (321,000), and Viet Nam (369,000). Several factors are associated with the increasing risk of dengue epidemic spread including: the changing distribution of the vectors (*Aedes aegypti* and *Aedes albopictus* are two main vectors transmitting dengue globally), especially in previously dengue naïve countries; the consequences of El Niño phenomena in 2023 and climate change leading to increasing temperatures and high rainfall and humidity; fragile health systems in the midst of the COVID-19 pandemic; and political and financial instabilities in countries facing complex humanitarian crises and high population movements [8, 10].

In Vietnam, the two mosquito species responsible for transmitting dengue are *Ae. aegypti* and *Ae. albopictus*, with *Ae. aegypti* being the more important vector [1]. In Hanoi, over the past 25 years, several large dengue outbreaks have been recorded, such as in 1998, with Dengue virus type 3 was found to be the main cause. In 2009, the total number of cases in northern Vietnam was 18,485, with 16,090 cases in Hanoi, accounting for 87% of the total number of cases in the region, and 4 deaths were reported. In 2015, another dengue outbreak was recorded in the northern region with 16,913 cases, 90% of which Hanoi reported 15,412 cases. Dengue virus types 1 and 2 were the main causes of this outbreak. In 2017, a widespread dengue outbreak occurred across the city, with 37,651 cases and 7 deaths reported [2]. In 2022, there were 20,035 cases and 25 deaths. In 2023, 40,502 cases and 4 deaths were recorded. Currently, dengue situation across the country as well as in Hanoi, continues to evolve in a complex manner.

Recently, the TAK-003 dengue vaccine has been licensed for use and introduced into vaccination programs in Vietnam, and it is considered part of an integrated strategy to control dengue. However, until the efficacy-risk balance of the TAK-003 vaccine for DENV3 and DENV4 in seronegative individuals is further evaluated, effective vector control interventions are still key to the prevention and control of dengue [11]. Therefore, continuing assessments of the distribution of dengue cases and identifying the distribution of vectors are necessary, as these serve as the basis for implementing appropriate interventions for different areas in the future.

## 2. Methods

### *2.1. Research subjects*

Confirmed cases of dengue reported during 2018-2020.

Mosquitoes and larvae of the two species *Ae. aegypti* and *Ae. albopictus* were collected at the surveillance sites.

### *2.2. Research locations and timeframe*

The study was conducted in 30 districts of Hanoi.

Duration: from January 2018 to December 2020

### *2.3. Methods*

- Study design: retrospective study

- Dengue surveillance data:

Data collection on dengue patients: information of all cases were collected from the annual dengue surveillance reports of the Hanoi Center for Disease Control (Hanoi CDC), following the Vietnam national guidelines for dengue prevention and control. Other arboviral infections, particularly Zika and chikungunya, could be clinically misdiagnosed as dengue; however, no Zika and Chikungunya cases have been previously reported in Hanoi, so this would be unlikely to substantially impact results.

Data collection on dengue vectors: Data on Aedes species composition, mosquito indices and larvae were collected from surveillance sites between 2018 and 2020 through the annual dengue surveillance reports of the Hanoi Center for Disease Control and several monitoring campaigns conducted by the Entomology Department of the National Institute of Malariology, Parasitology, and Entomology. The data include species composition, mosquito density, distribution, and the coordinates of Aedes mosquito survey sites from 2018 to 2020. All data will be entered into Excel 2010, cleaned, and analyzed.

The Aedes mosquito and larvae collected at survey sites had geographical coordinates (longitude, latitude) measured at the mosquito survey locations.

- Map creation: QGIS version 3.22 software was used to create the map. QGIS is an open-source map editing software that is available for free use.

## 3. Results and discussion

### *3.1. Aedes mosquito and larvae collected from survey sites and number of dengue cases from 2018 to 2020*

Table 3.1. Aedes mosquito and larvae collected from 2018 to 2020.

| No | Species | Number of surveyed sites | Number of sites with mosquitoes | Number of sites with larvae |
|---|---|---|---|---|
| 1 | *Aedes aegypti* | 65 | 57 | 58 |
| 2 | *Aedes albopictus* | 65 | 51 | 60 |

Table 3.2. Dengue cases in Hanoi in 2018, 2019 and 2020

| Year | Number of communes / wards with cases | Number of cases |
|---|---|---|
| 2018 | 409 | 4,531 |
| 2019 | 505 | 12,243 |
| 2020 | 472 | 6,787 |

### *3.2. Mapping the distribution of dengue cases and vector indicators in Hanoi, 2018*

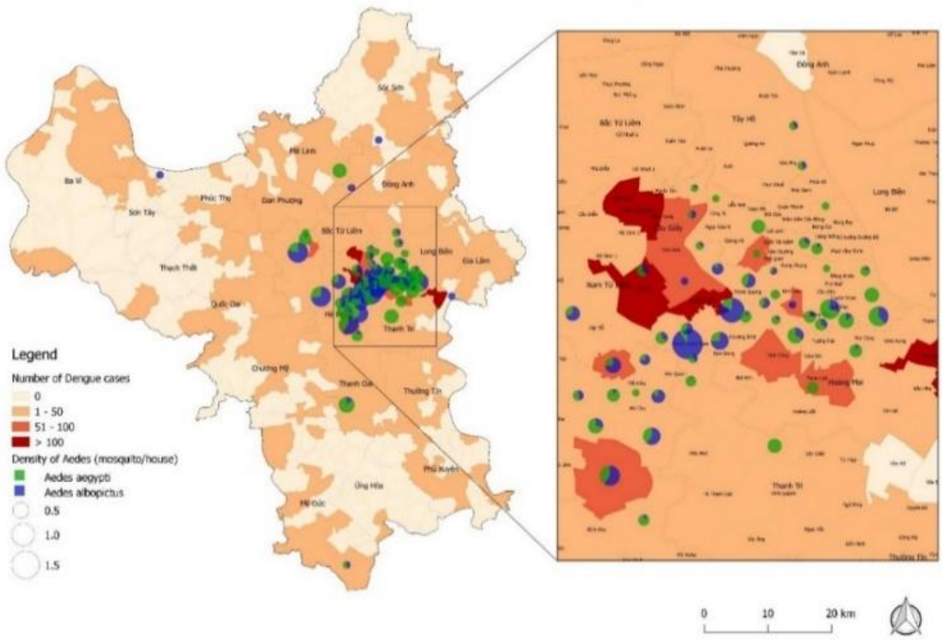


Figure 3.1. Distribution of dengue cases and density index in Hanoi, 2018

### *3.3. Mapping the distribution of DF cases and vector indicators in Hanoi, 2020*

Two maps for distribution of DF cases and adult mosquito density index, Breatau index in Hanoi from 2020, with database is presented in below Figures.

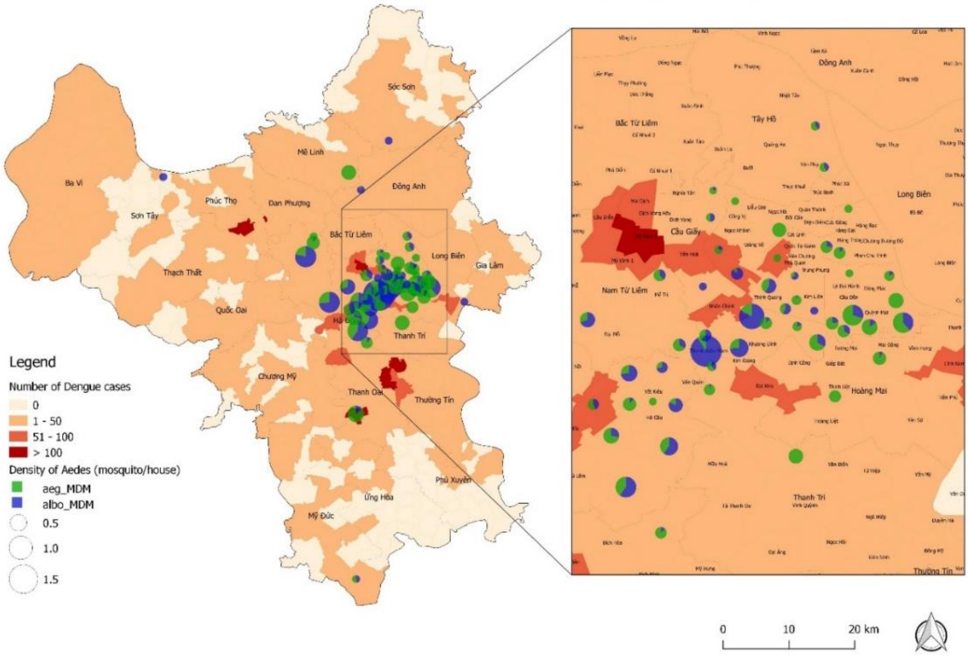


Figure 3.5: Distribution of dengue cases and density index in Hanoi, 2020

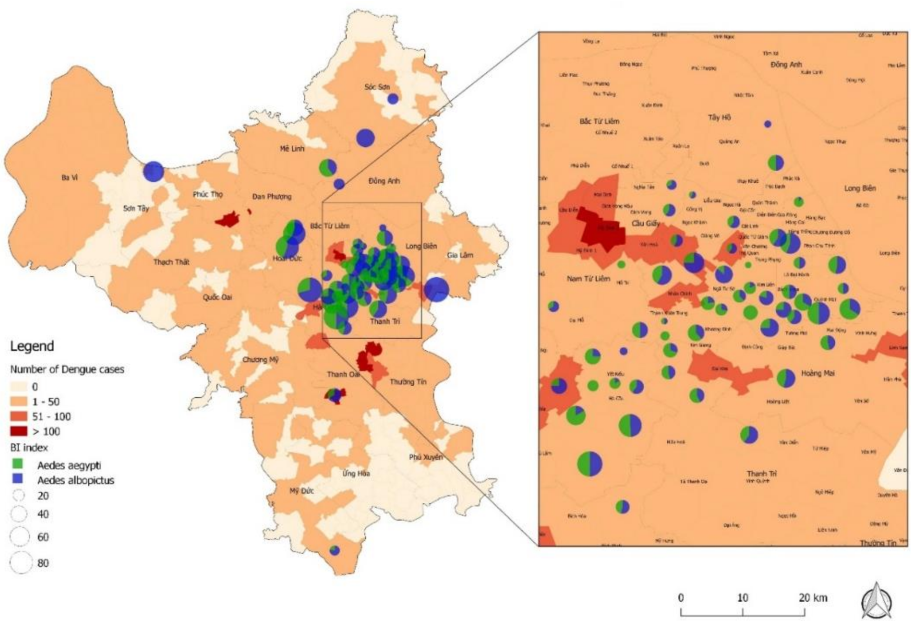


Figure 3.6. Distribution of dengue cases and Breatau index in Hanoi, 2020

The map shows that in 2020, there were 111 points with no reported cases, 452 points with 1-50 cases, 15 points with 51-100 cases, and 5 points with over 100 cases. Mosquitoes *Ae. aegypti* and *Ae. albopictus* were distributed across 10 districts: Hai Ba Trung (3 points), Thanh Oai (1 point), Hoan Kiem (1 point), Hoang Mai (1 point), My Duc (1 point), Dong Anh (1 point), Cau Giay (1 point), Hoai Duc (3 points), Thanh Tri (1 point), Dong Da (1 point), and ha Dong (2 points), with varying mosquito density indices. At the 16 points with Aedes mosquitoes, the density and Breteau Index (BI) of *Ae. aegypti* were higher than those of *Ae. albopictus*; these points also reported high case numbers exceeding 50 (Figure 3.5-3.6).

**4. Disscusion**

Over the three years of investigation, there were differences each year. The cases of Dengue varied by year. In 2018 and 2020, the number of points with no reported cases was over 100, while in 2019, there were 78 points. The number of points with over 100 cases in 2019 (20 points) was four times higher than in 2018 (3 points) and 2020 (5 points). The number of points with 51-100 cases in 2019 was 3.9 times higher than in 2018 (13 points) and 2020 (15 points), while the number of points with 1-50 cases showed minimal variation over the three years.

The analysis of the map indicates similarities among districts, with points lacking reported cases of DF primarily concentrated in the outskirts, such as My Duc, Ung Hoa, Phu Xuyen, Chuong My, Ba Vi, Son Tay and Soc Soc. In contrast, points with a high number of cases (51-100 and over 100) were mainly found in inner-city districts: Ba Dinh, Hai Ba Trung, Hoan Kiem, Cau Giay and Hoang Mai. At all points, the majority had 1-50 cases. This discrepancy may be attributed to differing levels of urbanization between inner and outer city points. In the outer areas, places considered ideal for the breeding and development of Aedes larvae, such as construction sites and discarded containers, are less frequent compared to the inner city, leading to lower Aedes adult mosquito density and larvae, especially of the species *Ae. aegypti*, compared to adjacent and inner-city points.

At all investigation points, the presence of Aedes mosquitoes was detected. The points with higher adult mosquito and larvae indices of the species *Ae. aegypti* compared to *Ae. albopictus* mostly had a high number of DF cases. In some study locations such as Dong Anh and My Duc, although cross-sectional surveys did not collect the primary disease vector *Ae. aegypti*, cases of DF still appeared and persisted. Therefore, it is necessary to expand and conduct deeper research on the species composition as well as the role of disease transmission by *Ae. aegypti* and *Ae. albopictus* at these locations.

Based on recent studies of the DF epidemic situation, it is clear that the DF will continue to develop complicatedly nationwide and in Hanoi in the coming time. Therefore, proactive prevention work is extremely important. Annually, localities need to take the initiative in measures such as preparing supplies and equipment, developing plans, and implementing coordinated measures to handle outbreaks as per regulations to prevent widespread outbreaks, thereby contributing to the protection of public health.

## 5. Conclutions

In Hanoi, cases are still mainly concentrated in the inner city area and tend to expand to bordering areas such as Thanh Oai, Phu Xuyen, Thanh Tri, Thuong Tin, Hoai Duc, and Dan Phuong districts.

At all investigation points, the presence of Aedes mosquitoes was detected. The points with higher adult mosquito and larvae indices of the species *Ae. aegypti* compared to *Ae. albopictus* mostly had a high number of DF cases.

## References

1. Ministry of Health (2014), Guidelines for surveillance and prevention of dengue fever. Decision No. 3711/QD-BYT, dated September 19, 2014..
2. Ministry of Health, National Dengue Fever Prevention Project (2018), Summary of national dengue fever prevention work in 2017.
3. Tran Thanh Duong, Nguyen Van Dung et al. (2019), Key to mosquito identification to species of genera of the Culicinae subfamily in Vietnam, Medical Publishing House, Hanoi.

4. Nguyen Van Dung, Nguyen Manh Hung, Nguyen Van Chau, Pham Thi Khoa, Nguyen Thi Bich Lien, Tran Thi Loan, Phung T. Phuong Thao, Ho Dinh Trung et al. (2011), Indices of mosquitoes, larvae and sensitivity to insecticides of Aedes vector in some northern provinces, period 2009-2010, Scientific Work, Report at the 38th Parasitology Conference, Medical Publishing House, 2, pp.186-195.
5. Nguyen Van Dung, Pham Thi Khoa, Tran Thanh Duong, Ho Dinh Trung et al. (2013), Evaluation of sensitivity to some insecticides of Aedes aegypti and Aedes albopictus mosquitoes at some locations in Hanoi and Quang Ninh in 2012, Journal of Malaria and Parasitic Diseases Prevention, 1, p. 53.
6. Vu Sinh Nam (1995), Some biological and ecological characteristics and measures to prevent and control dengue fever vectors in some localities in Northern Vietnam, PhD thesis in Medicine and Pharmacy, National Institute of Hygiene and Epidemiology, Hanoi, Ministry of Health, pp. 3-47.
7. Herbert, E. W., Perkins, P. V. (1973), Comparative tests of five insecticides against Aedes albopictus larvae from south Vietnam, Mosquito news, 33 (1), pp. 76-78.
8. WHO (2022), Dengue and severe Dengue, Updated 10 January 2022
9. World Health, O., Dengue: Guidelines for Diagnosis, Treatment, Prevention and Control. Dengue: Guidelines for Diagnosis, Treatment, Prevention and Control. 2009, Geneva: World Health Organization. 1-147.
10. WHO (2024), Dengue and severe Dengue, 2024.
11. WHO (2024), Dengue - Global situation, Updated May, 2024.

# Efficiency of pretreating anaerobic digestion of food waste in Phu Thuong - Ha Noi traditional rice processing village

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**Abstract:** Currently, the effective treatment of urban solid waste is an urgent problem for urban areas, especially in developing countries; of which Hanoi is a typical example. Effective treatment of solid waste in urban food processing and use can reduce urban pollution and enhance the exploitation of on-site renewable energy - a biological source with a gas content of about 50 - 60% [1].

Phu Thuong, traditional processing of sticky rice; is one of 1,350 craft villages in Hanoi. Every day, 600 families are making sticky rice, banh chung, and sticky rice wine to deliver to all over Hanoi [2]. As well as tens of thousands of food processing villages across the country. Residues from these activities are a source of serious pollution for the environment of craft villages and surrounding communities.

The experiment was conducted from residual product samples of Xoi Phu Thuong village with waste divided into 2 cases: unheated waste and heated waste. The results show that the difference in biogas generation efficiency between these two types of solids is about 56.4 - 63.5% in the anaerobic digestion (AD) experiment, batch, 2 stages, maintaining a temperature of 30 - 37 $^0$C to prioritize bio-gas generation. The difference in gas production efficiency between the unheated control case and the heated experimental case is 15.0%. Experiments have found the feasibility of Pre-heating of food waste treatment before anaerobic

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digestion.

*Keywords:* Food Solid waste, Ha Noi traditional rice, Efficiency of pretreating, pretreating anaerobic digestion.

## 1. Introduction

Quickly introducing food solid waste treatment technology into the community has practical significance for environmental protection and sustainable development. Many studies have shown positive and negative factors affecting the speed and efficiency of the AD process. Proper temperature increase is a positive factor in the speed and efficiency of the digestion. However, in developing countries, heating techniques during processing are hindered because this technique often increases equipment, operating and costs. The experiment here was conducted with input of unheated and heated rice waste collected from Phu Thuong sticky rice craft village - Hanoi to examine the differences in processing speed and efficiency of these case and control.

## 2. Content

### *2.1. Model*

Experiment using a 2-stage anaerobic incubation model, discontinuous, without adding additives.

### *2.2. Materials*

The experiment was conducted on a control of unheated residues (rice residues, raw beans, wrapped leaves) collected from households engaged in the traditional profession of cooking sticky rice and banh chung; Homogenize and standardize the sample and then divide the sample into 2 kind of wastes: unheated - control and heated - case.

### *2.3. Evaluation criteria*

Experiment to monitor input waste mass, output waste mass, conversion percentages, conversion speeds; bio gas production efficiency between cotrol (unheated) and case (heated).

### *2.4. Experimental results*

Table 1 shows the experimental results of 2 experimental models (heated) and control model (unheated) before being subjected to anaerobic digestion; with residual waste weight from 56.4% to 63.5%; gas production efficiency from 0.14 liters/g to 0.16 liters/g of waste; faster digestion time (from 35 to 32 days).

Table 1. Results of Pre-heating efficiency of AD on food waste in Ha Noi

| Parameter / Sample | WM in (kg) | WM out (kg) | Efficiency (%) | Gas productivity (Nl/g) | Duration (Day) |
|---|---|---|---|---|---|
| Unpre-heated waste | 2,00 | 0,87 | 56,4 | 0,14 | 35 |
| Pre-heated waste | 2,00 | 0,73 | 63,5 | 0,16 | 32 |

Abreviations: WM = Waste Mass; Nl = Normal litre; AD = Anaerobic Digestion

## 3. Comments

### *3.1. Treatment efficiency:*

The results in table 1 show that the effectiveness of the experiment is within the general estimate of 44% of the gas production rate of food waste [3]. There is a difference between the two experimental models and the control model. Compared with the unheated AD model, the pre-heating AD model has residual waste weight decreased by 16.3%; gas production efficiency increased by 15.0%.

### *3.2. Processing speed:*

The results in table 1 and fugure 1 show that the Anaerobic digestion time of the heating pretreatment model for waste before AD is 8.6% faster than the un-heating model. Thermophilic AD (55-70 °C) has a rate-advantage over mesophilic digestion (37 °C) as a result of its faster reaction rates and higher-load bearing capacity [6]. This pre-heating treatmant can be feasible to apply for community by collecting residue and waste then heating, drying, storing for continual AD to produce biogas.

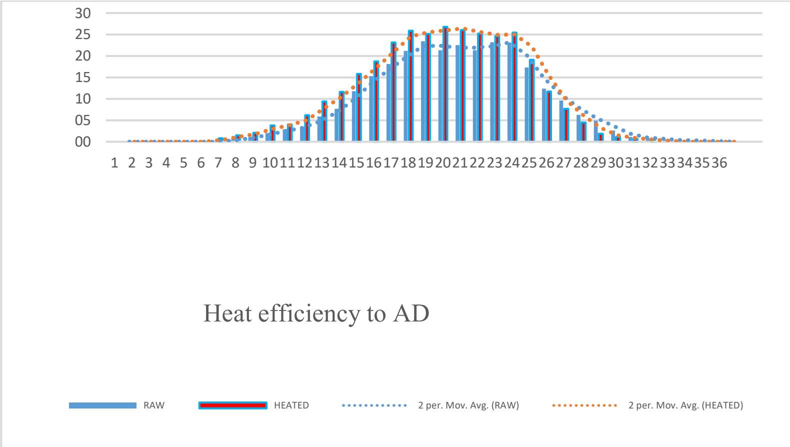


Figure 1. Pre-heating efficiency in AD

## 4. Conclusions

### *4.1. Heating efficiency before AD*

Experiments show that heating solid food waste once before anaerobic digestion can increase treatment efficiency. Further research can be done to maximize this one-time heat treatment solution to create maximum efficiency and increase the feasibility of the technique [4].

### *4.2. Applicability to the community*

Experiments comparing the performance of anaerobic digesting of solid food waste at a grain processing village in Hanoi show that: Heating during anaerobic digesting is more reasonable for big scale to apply than small scale due to increased technology and costs [5]. Meanwhile, heating solid waste once before putting it into anaerobic digesting is more reasonable for a small scale in the community.

## Acknowledgments

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## References

1. Dhamodharan Kondusamy, Ajay S. Kalamdhad. (2014). Pre-treatment and anaerobic digestion of food waste for high rate methane production. SceinsDirect, Journal of Environmental Chemical Engineering. Volume 2, Issue 3, September 2014, Pages 1821-1830
2. https://nhandan.vn/nghe-lam-xoi-phu-thuong-va-hanh-trinh-tro-thanh-di-san-van-hoa-phi-vat-the-quoc-gia-post796485.html
3. Dong-Hoon Kim 1, Jaehwan Cha, Mo-Kwon Lee, Hyun-Woo Kim, Mi-Sun Kim. (2013). Prediction of bio-methane potential and two-stage anaerobic digestion of starfish, Bioresour. Technol., 141, 184-190.
4. Nguyễn Thị Thu Hà, 2020. Đánh giá hiệu quả ủ kỵ khí một giai đoạn và hai giai đoạn trong xử lý chất thải rắn hữu cơ bằng thực nghiệm. Tạp chí Môi trường, số Chuyên đề Tiếng việt 2/2020
5. Nguyễn Thị Thu Hà, 2020. Xây dựng mô hình ủ kị khí thành phân hữu cơ trong chất thải rắn sinh hoạt. Tạp chí Môi trường, số Chuyên đề Tiếng việt 1/2020
6. Mao, C., Feng, Y., Wang, X., & Ren, G. (2015). Review on research achievements of biogas from anaerobic digestion. Renewable Sustainable Energy Rev., 45, 540-555.

# Feasible anaerobic digestion reactor for solid waste from Ha Noi small scale food processing

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**Abstract:** Urban areas in Vietnam currently have hundreds of craft villages processing agricultural and food products. Hanoi alone has up to 70 villages with thousands of households contributing. Phu Thuong, traditional processing of sticky rice; is one of 1,350 craft villages in Hanoi. Every day, 600 families are making sticky rice, sticky cake to deliver to all over Hanoi. As well as tens of thousands of food processing villages across the country; residues from these activities are a source of serious pollution for the environment of craft villages and surrounding communities.

Anaerobic composting technology in the world has developed in the past 20 - 30 years, especially in European countries, a series of anaerobic composting plants have been built to turn urban waste into an energy source. sustainable renewable energy.

For developing countries, small-scale anaerobic composting models will be more feasible. However, small-scale anaerobic incubators need to be designed to be simple and increase efficiency to be able to serve the community; make polluting waste into renewable energy sources; contribute to sustainable environmental protection.

Here, the anaerobic reactor is designed according to the principle of a 2-stage, continuous reaction, with simple liquid mixer/reverse pump, heater, alkalinity control partfor the gas-generating reactor, compact and

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lightweight; easy to install and use.

The model was tested with input waste collected from grain processing villages in Hanoi with treatment efficiency reaching 56.4 - 63.5% of waste. The cost to install a furnace with a capacity of 20 kg of input waste reactor ranges from $400-500. Users can collect solid waste from food processing and use residues; dried and stored as input material for this 2-stage, continuous anaerobic digestion model to produce gas for households.

*Keywords:* Food solid waste, Feasible anaerobic digestion, Small scale reactor.

## 1. Introduction

Waste treatment in most craft villages in Hanoi; currently, have no netwwork of collecting industry waste; no waste treatment system for exhaust gas, neither treatment for solid waste. Waste is only discharged directly into the environment. [1]. Among Hanoi's 1,350 craft villages, there are 70 food processing villages [2]. Of these, only about 10% meet environmental standards [3].

Quickly introducing food solid waste treatment technology into the community has practical significance for environmental protection and sustainable development. Currently, the trend of solid waste treatment in the world is to reduce landfill rates, increase recycling rates and biological composting. Many waste treatment plants using anaerobic methods in European countries and other regions have been built [4]. The current two-stage anaerobic digestion technology requires very high investment, operating costs and complex technology. Therefore, one-stage anaerobic incubation systems are still popular and applied to developing areas[5].

Solid waste from processing and using foods has quite high carbohydrate content. The rate of anaerobic digestion, creating biogas, is up to 50-60%. [6]. Currently, in Vietnam, the waste treatment trend often follows the one-stage anaerobic composting method to make fertilizer. Meanwhile, in urban areas and craft villages, the need to process waste as fertilizer is much lower than the need to process it to make biogas for cooking.

Therefore, the research team

reviewed, built, and experimented with a two-stage anaerobic incubator model to contribute to creating biogas treatment equipment to serve this practical need.

## 2. Content

### *2.1. Model*

Experimentally consider improving the 2-stage anaerobic incubation model to create the main product biogas with equipment requirements that are neat, easy to use, low cost, good efficiency, and can serve for households - small-scale treatment - solid waste treatment from food processing and use.

### *2.2. Input materials of the model*

#### *2.2.1. Input materials*

The experiment was conducted on a group of unheated residues (rice residues, raw beans, wrapped leaves) collected from households engaged in the traditional profession of cooking sticky rice and banh chung; Homogenize and standardize the sample, heat it (cook it), then dry it and package it for anaerobic incubation using a two-stage anaerobic incubation device.

#### *2.2.2. Equipment used*

The equipment used for two-stage anaerobic incubation is designed with the following characteristics (Figure 1).

### *2.3. Evaluation criteria*

Experiment to monitor input volume, output volume, conversion percentage, conversion speed; gas generation efficiency.

### *2.4. Experimental results*

#### *2.4.1. Output efficiency*

Table 1 shows the experimental results of the experimental model including anaerobic treatment and incubation. has a residual waste weight of 63.5%; gas production efficiency 0.16 liters/g of waste; incubation period 32 days.

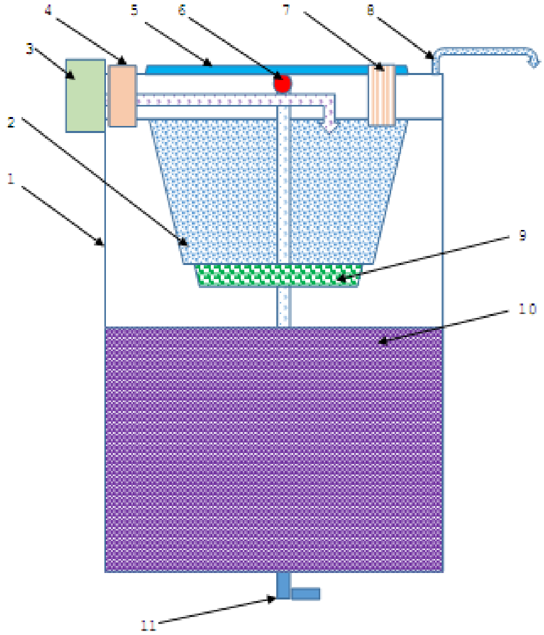


Figure 1: Schematic of small scale anaerobic digestion reactor

* Annotation: 1. Reactor tank, 2. Acidogenic reactor, 3. Conditioning tools, 4. Interrupt window, 5. Reactor cover, 6. Water pump, 7. Waste inlet, 8. Biogas out let, 9. Base layer, 10 . Biogasenic reactor, 11. Effluent valve.

*2.4.2. Operating principle of the device*

+ The raw material is solid food waste, which has been conditioned and put into the acidification reaction tank (2). Here, anaerobic bacteria catalyze the reaction that converts waste into liquid, organic acids - acides.

+ The acidic solution penetrates to the alkaline layer ($CaCO_3$), here (3) the acidic solution is adjusted to a neutral pH and then goes down to the biogasification reactor (9).

+ The biogasification reaction takes place here and when produced, it will be collected through the outlet (8).

+ Input materials can be added through the intake door/valve - airtight (7).

+ The gas generation part (10) can be stirred up by pumping fluid from the bottom of the vessel - heating, sampling, blowdown, reflux to the acidification reaction surface - by controlling the pump and valve/pump direction.

+ Large door (5) ensures tight sealing, creates anaerobic conditions, and is easy to manipulate and handle in the reaction vessel.

+ Small doors (4), convenient for checking and installing additional tools such as sensors, floats... without opening large doors; Ensure monitoring and system stability.

+ Auxiliary tools (3) for sampling, heating, alkaline addition...

+ Drain valve (11) to be able to clean, take samples, and discharge residue from the biogas generator.

Table 1. Results of Pre-heating efficiency of AD on food waste in Ha Noi

| Parameter / Sample | WM in (kg) | WM out (kg) | Efficiency (%) | Gas productivity (Nl/g) | Duration (Day) |
|---|---|---|---|---|---|
| Pre-heated waste | 2,00 | 0,73 | 63,5 | 0,16 | 32 |

Abreviations: WM = Waste Mass; Nl = Normal litre; AD = Anaerobic Digestion

## 3. Comments

### *3.1. Treatment efficiency*

The results in table 1 show that the effectiveness of the experiment is within the general estimate of 44% of the gas production rate for food waste [7].

### *3.2. Processing speed*

The results show that the Anaerobic digestion time of the model was 32 days, comparable to normal two - separate stage models.

### *3.3. Feasible to small scale solid waste treatment*

+ Neat model, easy to install, easy to operate for the community at low price. + An additional bottom can be added to facilitate heating and operate in high temperature mode - thermophilic (45 $^0$C - 55 $^0$C).

+ Adjusting the pH of the solution from the acid tank to the gas reactor is convenient and proactive with two options: increasing the pH with a solid base layer under the acid reactor and the option of adding alkali through the box (3).

+ Mixing is convenient with the

method of using a solution pump, instead of using a stirrer - higher cost, more susceptible to damage due to chemical environment, equipment performs fewer functions (only stirring) - This solution pump can also perform reflux from the gas generator to the acidification reactor, pump the solution out to take samples, and pump out sediment from the bottom of the gas generator when needed.

+ Can easily add input materials to run continuous digestion, instead of batch digestion as commonly seen in developing countries.

+Homogenization, heat treatment, drying, and standardization of input waste have allowed the processor's substrate to be retained, minimizing heat retention during the digestion process while still ensuring reaction speed - overcoming a complex operating procedure - having to maintain furnace temperature in previous two-vessel anaerobic digesters; so that the community can easily install and operate this treatment system.

## 4. Conclusions

### *4.1. Overall of the equipment*

The experimental equipment meets neat requirements, combining two reaction vessels into a neat uniform set.

### *4.2. Operation*

The experimental model has been tested to meet the requirements of treating solid waste and generating biogas like two separate tank designs.

### *4.3. Applicability to the community*

4.3. Testing the ability to apply this model to the community: Experiments on the anaerobic decomposition process of solids in a grain processing craft village in Hanoi show that: the operating model ensures the principle of decomposition to create gas with low cost ($400-500), easy to operate, easy to change according to the diverse needs of households.

## Acknowledgments

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## References

1. https://veia.com.vn/ha-noi-tap-trung-xu-ly-moi-truong-50-lang-nghe-o-nhiem-nghiem-trong.
2. https://qltt.vn/ha-noi-co-327-lang-nghe-lang-nghe-truyen-thong-99430.html.
3. https://vov2.vov.vn/doi-song-xa-hoi/nhung-thach-thuc-ve-o-nhiem-moi-truong-lang-nghe-ha-noi-46870
4. Nguyễn Thị Thu Hà, 2020. Đánh giá hiệu quả ủ kỵ khí một giai đoạn và hai giai đoạn trong xử lý chất thải rắn hữu cơ bằng thực nghiệm. Tạp chí Môi trường, số Chuyên đề Tiếng việt 2/2020.
5. https://ousar.lib.okayama-u.ac.jp/en/list/thesis_types
6. Kim, D.-H., Cha, J., Lee, M.-K., Kim, H.-W., & Kim, M.-S. (2013). Prediction of bio-methane potential and two-stage anaerobic digestion of starfish. Bioresour. Technol., 141, 184-190.
7. Dhamodharan Kondusamy, Ajay S. Kalamdhad. (2014). Pre-treatment and anaerobic digestion of food waste for high rate methane production. SceinsDirect, Journal of Environmental Chemical Engineering. Volume 2, Issue 3, September 2014, Pages 1821-1830.

# Typical properties of several forestry soils and cultivated soils in Bach Thong district, Bac Kan provinces

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**Abstract**: This article studies the soil quality of typical land use types in agriculture and forestry in Bach Thong district, Bac Kan province. Soil samples were taken on October 12-13 at 10 locations in Bach Thong district in 2023. Soil samples were analyzed for mechanical composition, pH, and organic carbon content. Analysis results show that the pH in soil samples taken in Bach Thong district usually ranges from acidic to very acidic, ranging from 3.65 to 5.32 in most soil samples. The highest organic carbon content is detected in protective forest soil samples, while lower organic carbon content values are found in productive forest soil samples. Organic carbon content in cultivated soil samples is lowest, especially in maize and rice crop samples. The acidic soil here is mainly due to sloping soil and sandy soil structure, so alkaline earth ions can easily be washed away, causing the soil to become acidic. Furthermore, organic carbon content is lower in productive forests and crop soil samples mainly due to sloping land without dense ground cover; organic carbon is easily washed away during heavy rain. Some suggestions for sustainable use of sloping land are increasing plant species diversity in afforestation, Cultivation along contour lines, and intercropping with the diversity of plants on sloping land to preserve soil to avoid erosion and washing away when heavy rain occurs.

*Keywords:* Contour lines; intercropping; organic carbon; productive forest; protective forest.

## 1. Introduction

Land is a valuable resource, one

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of the great resources for the country's economic development, especially in an agricultural country like Vietnam. Using land sustainably, economically, and effectively has become an important strategy affirmed by the Vietnamese government [1]. It is essential for the survival and growth of humanity because soil resources are inherently limited, and cultivable soil is even less. The soil quality depends in part on its inherent soil quality, which is determined by factors such as its parent material and topography, and also on its dynamic properties that management can change under a particular land use [2]

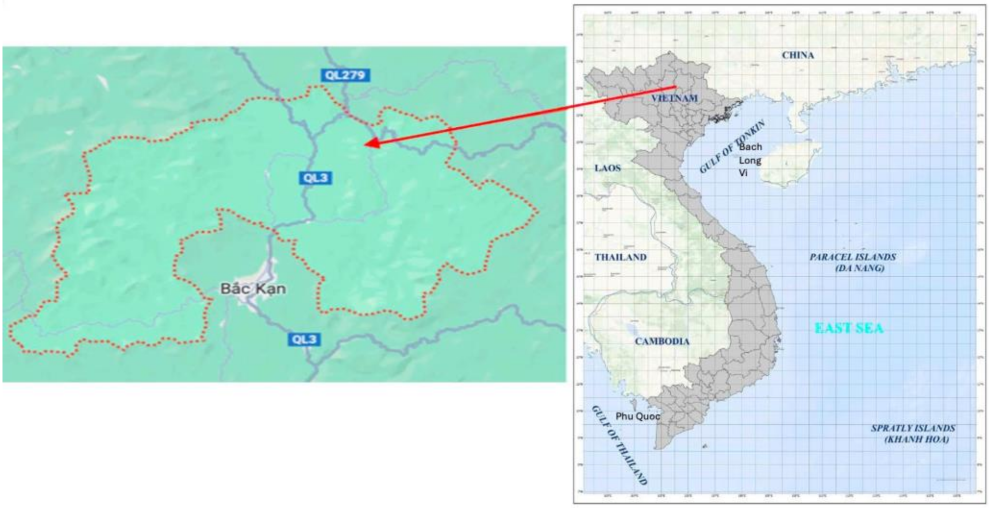


Figure 1. The geographic location of Bach Thong district - Bac Kan province.

Bac Kan is a highland province with a mountainous area of around 80% of the natural area; the terrain is rugged and strongly divided; flat land occupies a small area distributed into narrow strips, sandwiched between the strips, with high mountains on both sides. Most of the province's areas have steep slopes of over $15^0$, and people still cultivate (growing rice and other annual crops) in areas with over $20^0$. Bach Thong is in the center of Bac Kan province with geographical coordinates from $22^0$06' to $22^0$19' North latitude and from $105^0$39' to $106^0$ East longitude. Fig.1 is the geographic location of Bach Thong district - Bac Kan province.

The total natural area of the

district is 54,649 ha (equal to 11.23% of the total natural area of Bac Kan province). The topography of Bach Thong district is characterized by mountainous terrain, strongly divided with steep slopes, and the hilly direction is not homogeneous. The average elevation is (400 - 700) m above sea level. The highest terrain is 1,241m high [3].

Annual cultivation on steep slopes with improper techniques and disregarding soil fertility improvement causes soil degradation. This article studied and determined the status of soil quality in some sloping land areas in Bach Thong district, Bac Kan province, along with types of land uses, thereby finding out methods to use sloping land reasonably, prevent soil erosion, limit soil degradation, protect soil fertility, and ensure sustainable sloping land use.

## 2. Materials and methodology

### *2.1. Sample location, sampling time*

Soil sampling locations, purposes, and coordinates of soil sampling locations are in Table 1. Soil sampling locations are illustrated in Figure 2.

The soil of three main land use types, annual cropland use, productive forestland use, and protective forestland use, were selected for soil quality and sustainability assessment. Soil samples were taken at 10 locations in Bach Thong district in 2023, October 12-13th.

### *2.2. Methodology*

** Sampling method*

Soil sampling procedures are by sampling standards in the " TCVN 7538-2:2005 - Soil quality - Sampling, Part 2: Sampling technical instructions " [4]. Square plots of size 10m x 10 m were set up at each corner of these squares; take 1 kg of soil, mix well from this mixed sample, and take 1 sample of topsoil with representative vegetation to ensure the specificity of the area study. Soil was taken at a depth of 0-20cm.

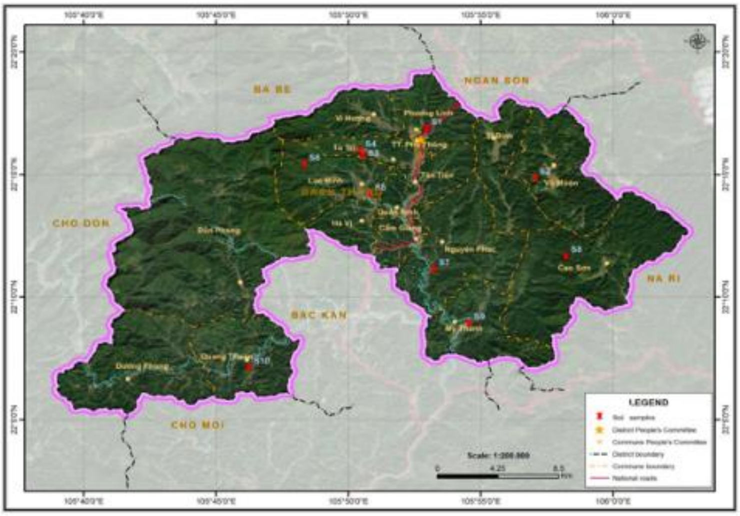


Figure 2. Soil sampling locations

* *Method of sample preservation*

Soil samples were taken for preliminary soil treatment according to TCVN 6647:2000 [5] before being transported to the Institute of Geography, Vietnam Academy of Sciences laboratory. At the laboratory, the soil samples were stored at about 2-5$^0$C and analyzed within 24 hours.

* *Method of soil sample analysis*

Soil samples were analyzed in the laboratory using the following methods: soil mechanical composition (unit %) was analyzed using TCVN 8567:2010; pH was analyzed using TCVN 5979:2007, and Organic carbon (unit %OC) was followed by TCVN 8941:2011.

## 3. Results and discussion

### *3.1. Mechanical composition and physical properties of Bach Thong district sample soils*

The mechanical composition of the soil is the content of different-sized elementary particles in the soil. The mechanical composition of the soil is expressed as a percentage of the weight of arid soil. Properties of the soil, its richness, and fertility, to a large extent, depend on the composition of the soil and the size of the particles. Table 2 presents the mechanical composition of soil samples at Bach Thong district.

The mechanical composition of

crop soil samples (S4, S5, S9, S10) was mainly medium mechanical composition and heavy mechanical composition. Compared to the USDA textural classes of soils, these soils almost belong to loamy soils with moderately fine texture, except the S5 sample (maize growing), which belongs to loamy soils with moderately coarse texture [6].

The soil texture of productive forest soil samples consists of S1 and S2 samples, which are clay loam and sandy clay loam, respectively. These soils also belong to loamy soils with a moderately fine texture [7].

The soil texture of the protective forest soil samples (S3, S6, S7, S8) was to be two groups; the first group is sandy clay (S3, S8) belonging to clayey soils with fine texture and the second group is loam belong to loamy soils with medium texture [6]. According to Le Van Khoa, the loamy soil group is less likely to be washed away than the other soil group above [1].

Acidity is one of the critical factors that determines soil fertility. It affects the soil's physical, chemical, and biological processes and significantly impacts plant survival and growth. Most plants prefer a neutral to slightly acidic soil reaction with a pH range of 6-7 [8].

Table 1. Soil sampling locations, purposes, and coordinates of soil sampling locations

| N | **Study sites** | **Signs** | **Coordinates** | | **Sampling purposes** |
|---|---|---|---|---|---|
| | | | **Latitude** | **Longitude** | |
| 1. | Phuong Linh commune | S1 | 22°16'50" | 105°52'57" | Mixed plant productive forest soil sample with level 3 slope. |
| 2. | Vu Muon commune | S2 | 22°14'50" | 105°57'02" | *Manglietia conifera* productive forest soil sample with level 2 slope. |
| 3. | Tu Tri commune | S3 | 22°15'44" | 105°50'33" | Mixed plant protective forest soil sample with level 3 slope. |
| 4. | Tu Tri commune | S4 | 22°15'56" | 105°50'27" | Cassava crop soil sample with level 2 slope. |

| | | | | | |
|---|---|---|---|---|---|
| 5. | Luc Binh commune | S5 | 22°14'10" | 105°50'49" | Maize crop soil sample with level 1 slope. |
| 6. | Luc Binh commune | S6 | 22°15'23" | 105°48'20" | Mixed plant protective forest soil sample with level 3 slope. |
| 7. | Nguyen Phuc commune | S7 | 22°11'06" | 105°53'14" | Mixed bamboo plant protective forest soil sample with level 2 slope. |
| 8. | Cao Son commune | S8 | 22°11'38" | 105°58'13" | Mixed plant protective forest soil sample with level 3 slope. |
| 9. | My Thanh commune | S9 | 22°08'54" | 105°54'33" | Rice crop soil sample with level 1 slope. |
| 10. | Quang Thuan commune | S10 | 22°07'05" | 105°46'14" | Tangerine cultivation soil sample with level 2 slope. |

*Note:* Level 1 slope: $0^0$ - $8^0$; Level 2 slope: $8^0$-$15^0$; Level 3 slope: $15^0$ - $20^0$

Table 2. Mechanical composition of soil samples at Bach Thong district

| Soil sample | Mechanical component | | | Textural class | Soil sample | Mechanical component | | | Textural class |
|---|---|---|---|---|---|---|---|---|---|
| | Sand | Silt | Clay | | | Sand | Silt | Clay | |
| S1 | 36,58 | 35,74 | 27,68 | Clay loam | S6 | 39,86 | 38,10 | 22,04 | Loam |
| S2 | 51,50 | 15,82 | 32,68 | Sandy clay loam | S7 | 45,82 | 38,08 | 16,10 | Loam |
| S3 | 43,60 | 14,58 | 41,82 | Sandy clay | S8 | 55,10 | 8,34 | 36,56 | Sandy clay |
| S4 | 49,38 | 15,46 | 35,16 | Sandy clay | S9 | 52,50 | 35,98 | 11,52 | Sandy loam |
| S5 | 66,10 | 14,32 | 19,58 | Sandy loam | S10 | 49,48 | 24,12 | 26,40 | Sandy clay loam |

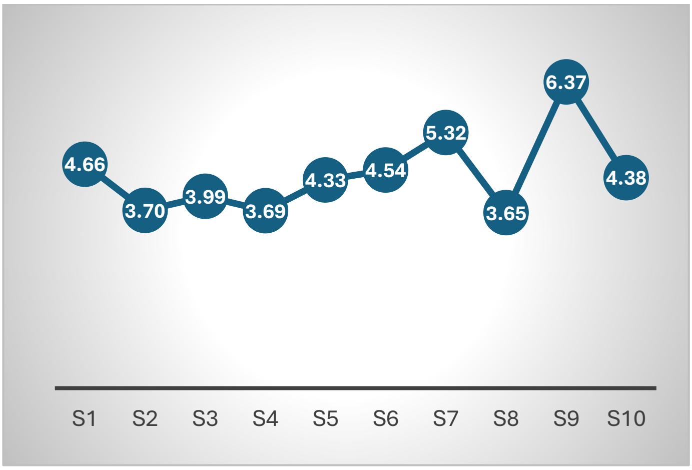


Fig. 3. pH of soil samples in Bach Thong district

The increased acidity of the soil neutralizes the activity of beneficial bacteria involved in the decomposition of peat, manure, compost, and other fertilizers. Bacteria help release nutrients found in plants in an accessible form [9].

The cause of the acidic soil here is mainly due to the sloping soil and sandy soil structure, so alkaline earth ions can easily be washed away, causing the soil to become acidic. S9 sample- Rice crop soil sample with level 1 slope (<8°) located at the down of the mountain, so it retains more alkaline earth ions, resulting in less soil erosion.

### *3.2. Nutrient composition in Bach Thong district sample soils*

Vietnam is located in a tropical climate; high temperatures and relatively high humidity cause the organic carbon mineralization process to take place vigorously, so the organic carbon content in soil is often poor, especially for long cultivation without organic fertilizers [10]. Comparing the organic carbon content in this study to the result of some other authors cultivating on sloping land [11,12], it is found that the organic carbon content in Bach Thong's soil belongs to the type of soil from poor to reasonably good. Organic matter is a unique component in almost all soil and is one of the most important indicators of soil fertility. In any ecosystem, steady-state organic carbon content is reached when carbon inputs to the soil match losses through respiration, leaching, and erosion. Analysis results show that organic carbon in arable soil ranges from 2,77 to 4,38%, the lowest in maize crop soil, higher in rice growing soil (3,41%), tangerine cultivation soil (4,38%) while the highest value in cassava soil (4,86%). This can be explained in the soil where corn and rice are grown in monoculture; the cultivating time is short; each year, there are 3 to 4 corn crops or two rice crops, the soil is continuously plowed, and there is no time to rest.

Meanwhile, cassava is an annual crop planted at the beginning and harvested at the end of the year. The soil rests around two months after each crop. The resting time is in the dry season when it rarely rains. Therefore, the soil is less affected by the rain. Furthermore, cassava is planted densely and along contour lines; the ability of cassava fields to retain soil and nutrients is much better than that of corn and rice fields. Farming on the contour reduces sheet and rill erosion and the resulting sediment deposition at the foot of the slope or off-site. It can increase water infiltration, thereby reducing the transport of nutrients and organics to surface water and increasing water storage in the soil profile [2,13]. Besides, in tangerine fields, tangerine trees are planted over time, year after year with dense bushes of grass under the ground such as *Brachiaria ruziziensis, Chrysopogon zizanioides, Panicum Maximum,…*, with strong roots improve the soil's physical properties, reduce acidity and increase the ability to hold Organic carbon in the soil by breaking down the solid soil layer, making the soil more porous and absorbent. The deep roots will take advantage of nutrients in the soil layers to create large biomass for soil protection, erosion prevention, and soil improvement and for producing on-site covering materials [8,14]. Fig. 4 presents the organic carbon in soil samples in Bach Thong district.

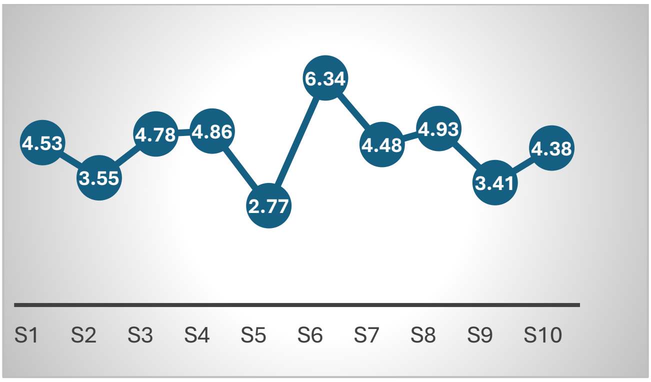


Fig. 4. Organic carbon (%) in soil samples in Bach Thong district soil samples

Organic carbon in productive forest soil samples (S1, S2) were 4,53% and 3,55% respectively. The S1 soil sample was from mixed plant productive forest soil with a level 3 slope, while the S2 soil sample was from manglietia conifera productive forest soil with a level 2 slope. The higher slope but more tree species diversity with dense aboveground tree layers caused the organic carbon retained in sample S1 to be higher than in sample S2. This demonstrates the significance of diverse tree layers and plant species for soil sustainability in storing organic carbon. This result is consistent with many cultivating studies on sloping soil [2,7, 8, 11].

Organic carbon in protective forest soil samples (S4, S6, S7, S8) were ranged from 4,48 to 6,34%. The highest organic carbon value was from mixed protection forests with a diversity of tree species formed from several forest layers with high stories consisting of timber trees such as *Chukrasia Tabularis, Fructus canarii, manglietia conifers,…* more than five years old were left over after forest exploitations five years ago, midstory trees with dense shrubs and grass layer in the surface layer. Humidity in this area is generally relatively high. High organic carbon content was detected with remaining protective forest soil samples but significantly lower than the S6 sample. Noticed an apparent reduction in the biodiversity of tree species in these forests. The lowest Organic carbon value was in a soil sample of mixed protection forests (S7) with mainly Bambusaceae family such as *Chimonoc alamus Avensis,* a few groups of grass growing on the ground, *Arundo donax L*, ... Lowest plant species diversity were discovered in this forest compare to another protective forest in this study. Due to illegal human exploitation, valuable wood trees were almost gone.

It was found that protective forest soil has an advantage over productive forest soil and cultivated soil because of plant diversity and forest layer diversity. However, the slope of the protective forest (level 3 slope) is higher than the slope of the productive forest (level 2 slope). The characteristics of these protective forests create high humidity in the forest, causing organic carbon to form. The soil here is reddish yellow mountain organic carbon. Thus, plant diversity once again proves its essential role in the soil formation process and is a determining factor in organic carbon richness in the soil.

### *3.3. Some proposals to improve and protect sloping land*

Many human activities should be implemented to increase the soil's ability to support forestry and agricultural production in the long term and benefit soil properties. The implementation of traditional methods has been observed, and it has also demonstrated remarkable effectiveness. Protecting sloping soil in forests and cultivating land by intercropping and increasing surface cover with strong and thick root system plants such as grasses (*Brachiaria ruziziensis, Chrysopogon zizanioides, Panicum Maximum,…*), legumes (*Leucaena leucocephala, Arachis pintoi, Cajanus cajan (L.) Millsp, Fructus Gleditschiae, Cassia siamea Lam.,…*),… get a good result in soil improvement that has been proven in this study and other experiments [3,11]. Plants with strong roots will improve the soil's physical properties, reduce acidity, and increase the ability to hold Organic carbon in the soil by breaking down the solid soil layer, making the soil more porous and absorbent. The deep roots will take advantage of nutrients in the soil layers to create large biomass for soil protection, erosion prevention, and soil improvement and for producing on-site covering materials. The amount and intensity of rainfall can influence the effectiveness of surface cover, but an increase in surface cover effectively reduces soil loss. These trends indicate that adequate surface cover is necessary to protect soil from erosion [15]. Besides, protecting and improving sloping soil in forests and cultivated land by cultivating trees along contour lines. Farming on the contour reduces sheet and rill erosion and the resulting sediment deposition at the foot of the slope or off-site. It can increase water infiltration, thereby reducing the transport of nutrients and organics to surface water and increasing water storage in the soil profile [2, 13]. It can also improve and protect sloping soil in forests and cultivated land by intercropping with nitrogen-fixing Legumes.

Legumes can form a symbiotic relationship with nitrogen-fixing soil bacteria called rhizobia. This symbiosis results in the formation of nodules on the plant root, within which the bacteria can convert N2 into NH3, which the plant can use. Only a few organisms that contain the genetic information needed to synthesize the enzyme nitrogenase possess the ability to convert gaseous $N_2$ into $NH_3$, which can then be biochemically modified to generate different organic forms of nitrogen [10]. In addition to providing bio-fertilizers, legumes cover crops and reduce soil erosion and leaching, as well as organic matter in the arable soil layer. Legumes help main crops grow healthier, more productive, and better withstand weather activities [16]. When rain comes, runoff is greater from mono-cropping plots than inter-cropping plots, whereas soil losses are significantly more significant from monocropping plots than intercropping plots [2, 11, 12]. Therefore, intercropping rows of legumes with main crops will be an excellent solution to help prevent erosion and nutrient leaching on sloping land.

**4. Conclusion**

Soil samples collected from Bach Thong district show that the medium dominates mechanical composition in crop soil samples, while in forest soil samples, heavy mechanical composition is dominant. pH often ranges from acidic to very acidic, fluctuating from 3,65 to 5,32. The cause of the acidic soil here is mainly due to the sloping soil and sandy soil structure, so alkaline earth ions can easily be washed away, causing the soil to become acidic. It is found that the organic carbon content in Bach Thong's cultivated soil belongs to the soil with fairly good organic carbon content in forest soil samples. The highest organic carbon content is detected in protective forest soil samples, while lower organic carbon content values are found in productive forest soil samples. Organic carbon content in crop soil samples is the lowest. High organic carbon values were discovered from land use with the diversity of tree species through higher slopes. Thus, plant diversity plays a vital role in soil formation and is a decisive factor in the richness of organic carbon in Bach Thong district, Bac Kan province.

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**References**

1. Le Van Khoa. Soil and environment. Education publisher, (2000).
2. Pierce, F.J. and W.E. Larson. 1993. Developing criteria to evaluate sustainable land management. p. 7-14. In: J.M. Kimble (ed.) Proceedings of the Eighth International Soil Management Workshop: Utilization of Soil Survey Information for Sustainable Land Use. (1993). USDA Soil Conservation Service, National Soil Survey Center, Lincoln, NE.
3. J.C. Castella, Dinh Quang Dang. Doi Moi in the mountains: Land use changes and farmers' livelihood strategies in Bac Kan province, Vietnam, The Agricultural Publishing House, (2002).
4. Ministry of Science and Technology TCVN 7538-2:2005 - Soil quality - Sampling, Part 2: Sampling technical instructions, (2005).
5. Ministry of Science and

Technology, TCVN 6647:2000 (ISO 11464:1994) - Soil quality - Preliminary treatment of soil for testing, (1994).

6. T.Phien, N. T. Siem. Sustainable farming on sloping land in Vietnam. Agriculture Publishing House, Hanoi, (1998).
7. USDA. Soil survey manual. Soil Survey Soil Conservation Service Volume Handbook 18, U.S. Department of Agriculture, (2017).
8. K. Zoljargal., D. Ikhbayar, T. Purevdorj. Effect of land use on soil organic carbon fractions. Mongolian Journal of Geography and Geoecology, Volume 43, (2022).
9. V.F. Valkov, K.S. Kazeev, S.I. Kolesnikov. Soil science. Publishing and Bookselling Center Mart, Moscow, (2004).
10. Vietnam Soil Science Association, Vietnamese Soil. Agriculture Publishing House, Hanoi, (2000).
11. T. Higashide. Soilless Culture on Sloping Land. Japanese Journal of Plant Science, (2007).
12. T. B. H. Nguyen and T. T. T. Nguyen. "Evaluating the efficiency of agricultural land use types in Yen Phuc commune, Van Quan district, Lang Son province" (in Vietnamese), Journal of Science and Technology, vol. 179, (2018), pp. 181-186.
13. Damasa Magcale-Macandog B., Ranola F. M., Roberto Ran˜ola Jr. F., Princess Alma Ani B., Nin Vidal B, Enhancing the food security of upland farming households through agroforestry in Claveria, Misamis Oriental, Philippines. Agroforest system journal, (2010).
14. and nutrient losses by water erosion under mono-cropping and legume inter-cropping on sloping land. Pakistan Journal of Agricultural Research, (2007).
15. J.S. Pate, Transport and partitioning of nitrogenous solutes. Annual Review of Plant Biology, 31, (1980), pp. 312-340.
16. A. Broghammer, L. Krusell, M. Blaise, J. Sauer, J. T. Sullivan, N. MaolanonLegume receptors perceive the rhizobial lipochitin oligosaccharide signal molecules by direct binding. Proceedings of the National Academy of Sciences, (2012). U.S.A. 109, 13859-13864

# Application of the PSO-SVR artificial intelligence model to predict air temperature in the blasting coal longwall at NamMau coal mine

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**Abstract:** With the development of Vietnam's economy, the demand for coal energy is increasing. Meanwhile, the resource reserves in the shallow parts are diminishing, leading to increasing mining depths in coal mines. Therefore, deep mining activities cause an increase in air temperature in underground coal mines. This results in deteriorating microclimatic conditions, particularly with a tendency for temperatures in mining areas to rise and exceed 30°C. According to the QCVN01:2011/BCT standard, mine air temperature should not exceed 30°C. Thus, this becomes a major issue affecting not only the mining process but also negatively impacting workers' health. Therefore, it is essential to accurately forecast air temperature in blasting coal longwalls to optimize solutions for improving the thermal environment in current underground mines. In this study, the temperature in underground mining areas has been forecasted using artificial intelligence models based on SVR and the PSO optimization algorithm. The SVR model is designed to forecast temperature and the PSO optimization algorithm is used to optimize the parameters of the SVR model to improve the accuracy of the traditional SVR model. The results of the paper show that the developed models can forecast mine air temperature with high accuracy. Among them, the PSO-SVR model provides higher accuracy than the traditional SVR model (RMSE = 0.16, $R^2$ = 0.95, MAE = 0.12), while the raditional SVR model only offers accuracy levels of (RMSE = 0.22, $R^2$ = 0.91, MAE = 0.18).

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*Keywords:* Longwall coal blasting, underground mining, PSO-SVR model, mine air temperat1.

## 1. Introduction

The Nam Mau coal mine is located approximately 25 km north of Uong Bi city. The mine is opened through a pair of inclined shafts at levels +125/-200. The primary coal extraction method involves drilling and blasting. Ventilation uses the exhaust ventilation method, with two main fan stations: the 2K56-N018 fan station located at level +210 and the FBCDZ-10-N03.5 fan station located at level +279, providing the required clean airflow to the consumption points. However, as mining operations go deeper, the microclimatic conditions at the Nam Mau coal mine become increasingly severe, affecting the workers. One of the most important parameters related to the underground mine's microclimate is temperature [1]. According to QCVN01:2011/BCT, the temperature in underground mines must not exceed 30°C[2]. This not only affects workers' concentration levels [3] but also poses a risk to occupational safety [4]. Therefore, many researchers have focused on developing models to forecast the temperature in underground mines, with the aim of proposing optimal solutions to minimize the impact of temperature on workers. For example, a multivariate regression model has been used to predict temperature in the ventilation system [5]. Truong Tien Quan and his research team predicted the air temperature in coal faces using an Artificial Neural Network (ANN)[6]. Meanwhile, an initial model in the C++ programming language was also proposed for a deep gold mine[7]. The forecasting results of these models have not been highly accurate and have not been applied to all areas. In recent years, Artificial Intelligence (AI) has become more popular and widely applied in various engineering fields. Among these, the Support Vector Regression (SVR) model has been proven to be an effective tool for solving nonlinear regression problems. However, it has also been proven that the accuracy of the SVR model largely depends on the choice of the kernel function and three hyperparameters, including the kernel parameter, regularization constant, and the epsilon-insensitive coefficient. Therefore, selecting the hyperparameters of SVR is a critical issue [8]. Currently, there are many popular optimization algorithms, with grid search and Genetic Algorithm (GA) [9] being the most common. However, these methods require a lot of time, space, and face various challenges in execution. Instead of using grid search and GA, Particle Swarm Optimization (PSO) is employed in this study. PSO is inspired by the social behavior of organisms such as bird flocks and fish schools. Due to its simplicity, fewer parameters, and ease of implementation [10], PSO has been successfully applied in various fields such as function optimization and neural network training .The purpose of this paper is to develop a PSO-SVR model to predict the temperature in coal faces. PSO is used to optimize the three hyperparameters of SVR. The SVR model with optimized hyperparameters is trained and tested using a dataset of parameters that affect the temperature in underground Vietnamese mines, aiming to achieve high correlation between the measurements and predictions.

## 2. Study Area and Data Used

### *2.1. Study Area*

The study area encompasses all long coal faces that use blasting technology supported by XDY, ZH and GK supports, with the explosive type being AH1, and an extraction output of 150 to 250 tons per year. The blasted coal face is illustrated in Figure 1.

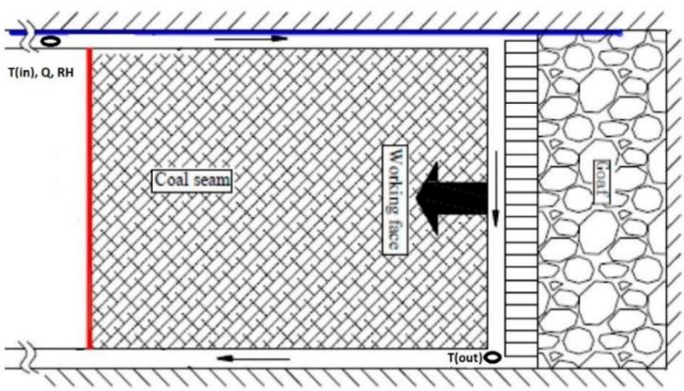



Figure1. Longwall area

### *2.2. The Data Used is Described as Follows*

The research team collected data from sensor devices as well as actual measurements at the mine. The data was gathered from the coal faces and includes the following parameters: input temperature in the coal face area, average air humidity, mining depth, length of the mining area, capacity of the mining equipment, airflow through the mining area, and output temperature of the coal face, as shown in Table 1.

Table 1: Summary of the Data Used in This Study

| Parameter | Min. | Mean | Max. | Std |
|---|---|---|---|---|
| T(in) | 24.6 | 27.09 | 28.4 | 0.73 |
| RH | 80 | 89.5 | 94.0 | 2.6 |
| Q | 5.4 | 7.23 | 9.18 | 0.84 |
| P | 115.5 | 129,2 | 140.0 | 10.11 |
| A | 416 | 564.24 | 698.0 | 78.78 |
| D | 30 | 40.55 | 50.0 | 7.59 |
| L | 172.54 | 250.53 | 364.0 | 51.91 |
| T(out) | 25.4 | 28.67 | 30 | 0.78 |

From Table 1, it can be observed that the input temperature in the coal face area T(in) ranges from 24,6°C to 28,4°C, the air humidity in the coal face RH ranges from 80% to 94%, the airflow provided to the coal face Q ranges from 5,4 to 9,18 $m^3/s$, and the power of the electrical equipment in the coal face area P ranges from 115,5 to 140 kW. The extraction output ranges from 416 to 698 tons, the mining depth ranges from 30 to 50 m, and the length of the mining area L ranges from 172,54 to 364 m. The output temperature of the coal face area T(out) ranges from 25,4 to 30°C. The frequency distribution of the dataset in this study is shown in Figure 2.

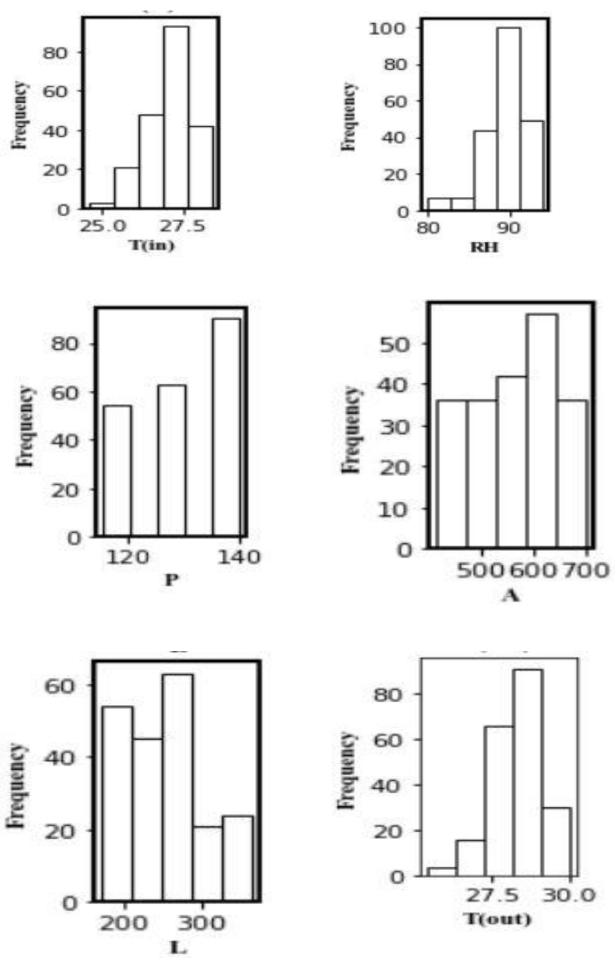



Figure 2. The frequency distribution of the dataset in this study

## 3. PSO-SVR Algorithm

The paper utilizes two algorithms: Support Vector Regression (SVR) and Particle Swarm Optimization (PSO). In this context, SVR is used to predict the temperature in the coal faces, while PSO is employed to optimize the parameters of SVR.

### *3.1 Support Vector Regression*

Support Vector Regression (SVR) is a machine learning algorithm based on the principle of minimizing structural risk to improve generalization capability on a limited number of samples, as proposed by Cortes and Vapnik [11] SVR can address both classification and regression problems. For regression tasks, SVR relies on a subset of training data to build the predictive model. The goal of the SVR model is to estimate the function f(x) with a deviation no greater than epsilon for all output values. However, the accuracy of the prediction results depends on the parameters of the SVR model, including the penalty parameter, the epsilon-insensitive loss coefficient, the kernel function, and the kernel parameters.

**Penalty Parameter (C)**: The penalty parameter is used to represent the error margin and determine the complexity of the SVR model, which is controlled by the number of support vectors. A small penalty parameter means there is a relatively large margin, resulting in a relatively simple model.

**Epsilon-Insensitive Loss Coefficient (ε)**: The epsilon-insensitive loss coefficient is used to measure the error margin of each data sample. It also controls the complexity of the model. A larger value for this parameter results in fewer support vectors and a simpler SVR model.

**Kernel Function**: The original feature space is mapped to a new feature space through the kernel function. Different kernel functions can produce different SVR models with varying regression functions, so changing the kernel function can lead to significant differences in the prediction results of the SVR model

Linear Kernel Function

Polynomial Kernel Function

Radial Basis Function Kernel

Here, r, d, γ, and σ are kernel parameters that can be adjusted for optimal predictive models. In summary, the selection of the penalty parameter, epsilon-insensitive loss coefficient, kernel function, and kernel parameters largely determines the quality of the SVR model, and these parameters depend on the specific data. Therefore, the PSO algorithm is used to optimize the parameters of the SVR model to minimize the prediction error of the SVR model. As a result, the SVR model for predicting the temperature in the coal face will be more accurate.

### *3.2. Particle Swarm Optimization Algorithm*

Particle Swarm Optimization

(PSO) was proposed by Dr. Eberhart and Kennedy in 1995 [12], with the aim of simulating the foraging behavior of bird species. In the PSO description, each bird is considered a particle, and each particle represents a potential solution at its location. In each iteration, a particle adjusts its position and velocity based on its individual optimal position, the global optimal position, and its previous position. The algorithm continues to iterate until a predefined termination condition is met. We define the position of a particle at time t as Xi(t). The position of particle i is represented in Equation (4)Xi(t): represents a multidimensional vector, and the number of dimensions depends on the number of parameters that need to be optimized. The velocity Vi(t+1) is represented in Equation (5)

$V_i$ (t + 1)= $\omega V_i$ (t) + $c_1$ $r_1$ (t)[pbest - Xi (t)] + $c_2$ $r_2$ (t)[gbest - $X_i$ (t)] (5)

$V_i$(t+1) can be initialized to 0 or a random value within a given range. ω is the inertia coefficient that describes the particle's ability to maintain its momentum. c1 and c2 are learning coefficients, usually equal to 2, while r1(t) and r2(t) are random values in the range from 0 to 1. Additionally, pbest represents the best position of a particle, and gbest represents the best position of all particles

$$P = (C, \gamma, \delta)$$

In this paper, the data samples are divided into two parts: one part constitutes 80% of the dataset for training, and the remaining part makes up 20% for testing. The prediction error of the testing data can characterize the generalization capability of the SVR model. Therefore, we use the root mean square error (RMSE) as the fitness function to evaluate the quality of the particles. RMSE is represented in Equation (6)

$$RMSE = \sqrt{\frac{1}{n}\sum\nolimits_{i=1}^{n}(y_i - pre_i)} \quad (6)$$

In the above equation, yi represents the measured value, prei represents the predicted value from the SVR model, and nnn is the number of testing data samples. A smaller RMSE indicates better fitness.

## 4. Results and Discussion

### *4.1. Performance metrics for evaluating models*

To evaluate the performance of forecasting models, performance indicators are used, including root-mean-square error (RMSE), coefficient of determination (R2), and mean absolute error (MAE), which are calculated using Eqs. (7-9), respectively.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i}^{n}(y_i - \hat{y}_i)^2} \qquad (7)$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y}_i)^2} \qquad (8)$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i| \qquad (9)$$

Where:

$Y_i$: the actual value of sample i: the corresponding predicted value, : the mean of the actual values, n: the total number of samples.

### *4.2. Evaluating forecasting models*

Based on traditional SVR forecasting models with different kernel functions and the developed PSO-SVR model, experimental datasets were used to evaluate the performance of the models according to the formulas above. For Support Vector Regression with a linear kernel (SVR-L), the penalty coefficient C is used to improve model accuracy. The polynomial kernel model (SVR-P) adjusts the penalty coefficient C and the degree, while the RBF kernel model (SVR-RBF) adjusts the parameters C and γ. The PSO-SVR model optimizes three parameters: C, γ, and ϵ. To enhance model accuracy and avoid overfitting, ten-fold cross-validation with three repetitions was used during model development. RMSE was used to optimize the models by minimizing its value. The resulting optimal parameters were as follows: (SVR-L) with C = 891.15; (SVR-P) with C = 1.67, degree = 2; (SVR-RBF) with C =1000, γ = 0.1; (PSO-SVR) with C=35.45, γ = 0.3, ϵ=0.08.

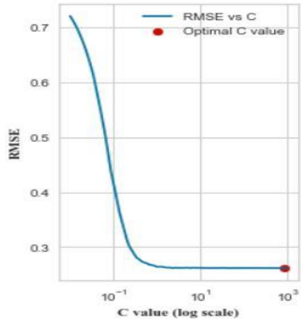



Figure 3. Model performance on training data for the SVR-L model

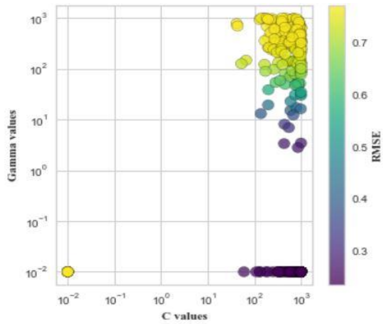



Figure 4. Model performance on training data for the SVR-P model

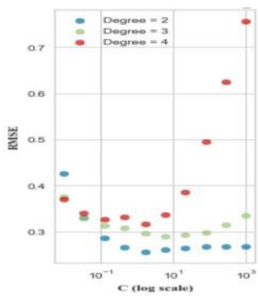



Figure 5. Model performance on training data for the SVR-RBF model

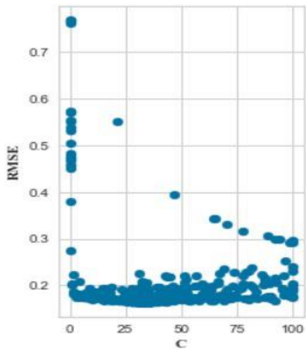



Figure 6. Model performance on training data for the PSO-SVR model

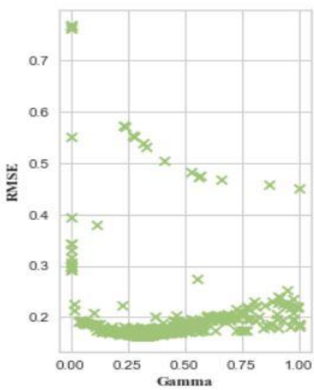



Figure 7. Model performance on training data for the PSO-SVR model

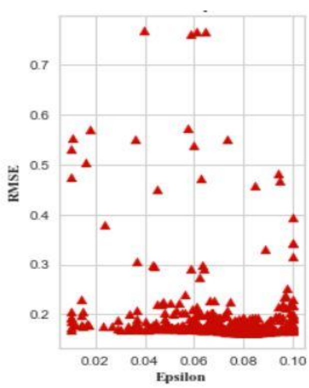


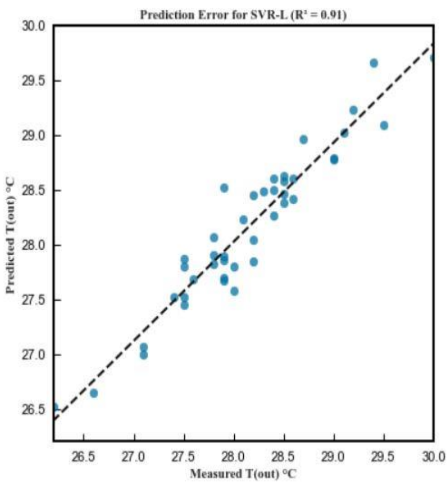

Figure 8. Model performance on training data for the PSO-SVR model

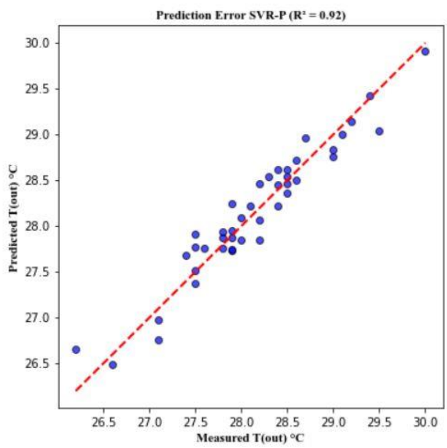
Accordingly, RMSE, $R^2$, and MAE are calculated on both the training and testing datasets.

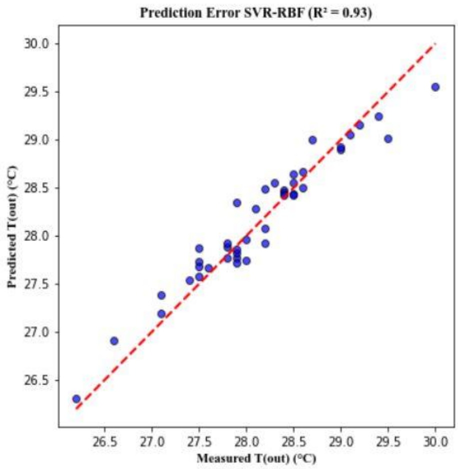
Table 2. Performance of forecasting models on the training and testing datasets

| Model | Training datasets | | | Testing datasets | | |
|---|---|---|---|---|---|---|
| | R2 | RMSE | MAE | R2 | RMSE | MAE |
| SVR-L | 0.9 | 0.24 | 0.2 | 0.91 | 0.22 | 0.18 |
| SVR-P | 0.92 | 0.22 | 0.17 | 0.92 | 0.2 | 0.17 |
| SVR-RBF | 0.93 | 0.21 | 0.17 | 0.93 | 0.19 | 0.15 |
| PSO-SVR | 0.95 | 0.18 | 0.14 | 0.95 | 0.16 | 0.12 |

From Table 2, we can see that all four developed models perform well in predicting the temperature at the Nam Mau coal mine drilling and blasting sites. Among them, the PSO-SVR model provides the best forecasting results with $R^2$=0.95, RMSE = 0.16, and MAE = 0.12, while the traditional SVR(L) model gives the lowest results with $R^2$=0.91, RMSE = 0.22, and MAE = 0.18 on the testing dataset. Figure 9 illustrates the forecasting results of the models





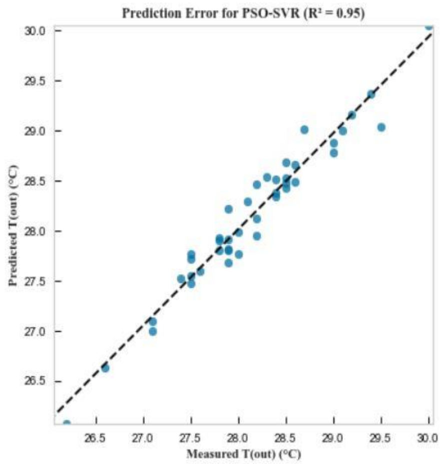




Figure 9. The relationship between measured and predicted values of the predictive models on testing datasets

## 5. Conclusion

Currently, as mining operations go deeper, the air temperature in underground mines is increasing, which affects the health of workers and compromises safety in production. It is a fundamental parameter for forecasting and controlling microclimates in underground mines. Accurate temperature forecasting is crucial for production safety and optimizing measures to protect workers.

(1) The temperature in mining faces numerous influencing factors, and the relationships between them are nonlinear and complex. The SVR method can better handle these nonlinear relationships.

(2) The kernel functions and parameters of traditional SVR models significantly impact the accuracy of SVR. Through evolutionary algorithms, optimal values for kernel functions can be achieved for the SVR model.

(3) PSO is the most dominant evolutionary algorithm when combined with the SVR model for predicting underground mining temperatures, yielding more accurate results than traditional SVR models. This should be recognized as a powerful technique for accurate temperature forecasting.

## References

1. Yi, X; Ren, L; Ma, L; Wei, G; Yu, W; Deng, J; Shu, C. Effects of seasonal air temperature variation on airflow and surrounding rock temperature of mines. Int. J. Coal Sci. Technol. 2019, 6, 388-398
2. Ministry of Industry and Trade of Vietnam,National technical regulation on safety in underground coal mining QCVN 01: 2011 / BCT
3. Mazlomi, A.; Golbabaei, F.; Farhang Dehghan, S.; Abbasinia, M.; Mahmoud Khani, S.; Ansari, M.; Hosseini, M. The influence of occupational heat exposure on cognitive performance and blood level of stress hormones: A field study report. Int. J. Occup. Saf. Ergon. 2017, 23, 431-439
4. Varghese, B.M.; Hansen, A.; Bi, P.; Pisaniello, D. Are workers at risk of occupational injuries due to heat exposure? A comprehensive literature review. Saf. Sci. 2018, 110, 380-392.
5. Bascompta M, Rossell J. M, Sanmiquel L, i Anticoi H, paź.Temperature Prediction Model in the Main Ventilation System of an Underground Mine. 2020 Appl. Sci., t. 10, nr 20, s. 7238.
6. Truong Tien QUAN, Klaudia ZWOLIŃSKA-GLĄDYS, Rafał ŁUCZAK, Marek BOROWSKI. Application of ANN Artificial Neural Networks to Predict Air Temperature in Longwall Workings of Vietnamese Anthracite Mines. Inżynieria Mineralna. 10.29227/IM-2023-02-60
7. Lyu, W.; Cai, S.; Yang, P.; Zhang, Y. Underground environment parameter prediction in a deep mine. Deep mining 2017, Proceedings of the Eighth International Conference on Deep and High Stress Mining, Australian Centre for Geomechanics, Perth, pp. 949-960, https://doi.org/10.36487/ACG_rep/1704_65_Lyu.
8. Vladimir Cherkassky, Yunqian Ma. Practical selection of SVM parameters and noise estimation for SVM regression. Neural Networks. Volume 17, Issue 1, January 2004, Pages 113-126. https://doi.org/10.1016/S0893-6080(03)00169-2.
9. Liu Qingjie, Chen Guiming, Liu Xiaofang, Yang Qing. Genetic algorithm based svm parameter composition optimization. Computer Applications and Software, 2012, 29(4):94-96.
10. Bo Liu , Ling Wang, Yi-Hui Jin, An effective hybrid PSO-based algorithm for flow shop scheduling with limited buffers. Computers &

Operations Research. Volume 35, Issue 9, September 2008, Pages 2791-2806. https://doi.org/10.1016/j.cor.2006.12.013

11. Cortes C, Vapnik V. Support vector machine. Mach Learn 20(3):273-297 (1995)
12. Eberhart R, Kennedy J. A new optimizer using particle swarm theory. 1995

# The features of the use of protective measures against the effects of noise by freelancers at some intersections and road intersections in Thai Nguyen city

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**Asbtract:** A cross-sectional study in Thai Nguyen city was conducted to describe the features of the use of protective measures against the effects of noise by freelancers at some intersections and road intersections in Thai Nguyen city for 212 freelancers from April 2023 to April 2024. The results showed that the proportion 43.4% of workers use protective equipment to limit noise impact, the remaining 56.6% do not use protection; 31.5% use hats that cover the ears, 22.8% use earplugs, and 21.7% use ear caps. Within the group of workers using protective equipment, 46.7% use it regularly, while 53.3% use it occasionally. There is a correlation between regular health check-ups, the overall sound pressure levels at intersections, and the use of protective equipment ($p<0.05$ and $p<0.001$).

*Keywwords:* Thai Nguyen, freelance worker, noise.

## 1. Introduction

Due to rapid urbanization, traffic noise along roads is constantly increasing [1]; Road traffic noise contributes 66.0% of total noise pollution in urban areas and negatively impacts personal

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health and quality of life; In particular, those who work at intersections, traffic intersections, etc. are significantly affected. In addition, intersections are the most complex part of the road network with relatively higher adjacent residential areas and complex traffic flows, resulting in higher traffic conflict points, delays and traffic noise pollution [2]. Long-term exposure to traffic noise has negative effects on health. Based on data reported in 2017, it is estimated that in Europe at least 18 million people are highly annoyed due to long-term exposure to traffic noise and 5 million people suffer from sleep disorders [3]. Determination of the use of noise control devices by freelancers at intersections and intersections in the city play a very important role in preventing and controlling noise pollution as well as protecting and caring for the health of workers. For this reason, we conducted a study with the following objectives: *Describe the features of the use of protective measures against the effects of noise by freelancers at some intersections and road intersections in Thai Nguyen.*

## 2. Methods

*Study populaiton*

Freelancers at intersections and intersections in the city of Thai Nguyen

*Palce and time*

From March 2023 to March 2024 in the Thai Nguyen city.

Study design

Descriptive cross-sectional research

Sample size

All freelance workers at intersections and junctions in Nguyen City were purposively selected. In fact, we conducted a survey of 212 freelance workers at intersections and intersections in Thai Nguyen City.

Variables

General characteristics of research subjects

Proportion of workers using noise-reducing protective equipmentCommon types of noise-reducing protective equipment

Level of use of noise-reducing protective equipmentSome reasons why workers do not use noise-reducing protective equipment

Some factors associated with the use of noise-reducing protective equipment Workers' protective equipmentSome signs of functional effects of noise by workers

Data collection

- Conduct interviews using semi-structured questionnaires.

- Measure noise at traffic intersections

Statisstical analysis

- The data were cleaned and enter data using the Micosoft Excel 2016.

- Data are analyzed with the SPSS 25.0 program: using descriptive statistics with calculations of frequencies, percentages, averages, standard deviations.

**3. Results**

Table 1 General characteristics of the study population

| **Characteristics** | **n** | **%** |
|---|---|---|
| ***Sex*** | | |
| *Men* | 76 | 35.8 |
| *Women* | 136 | 64.2 |
| ***Age*** | | |
| <18 | 3 | 1.4 |
| 18-60 | 190 | 89.6 |
| >60 | 19 | 9.0 |
| ***Working hours/day*** | | |
| <8 hours | 17 | 8.0 |
| 8 hours | 26 | 12.3 |
| >8 hours | 169 | 79.7 |
| **Experience working at intersections** | | |
| < 4 years | 159 | 75.0 |
| 4-10 years | 45 | 21.2 |
| >10 years | 8 | 3.8 |

The result from Table 1 shows that 64.2% of employees were female, of which 89.6% were aged 18 to 60 years; The working time per day at intersections was usually more than 8 hours, accounting for 79.7%, and the work experience was 75.0% under 4 years, followed by 4 to 10 years, accounting for 21.2%

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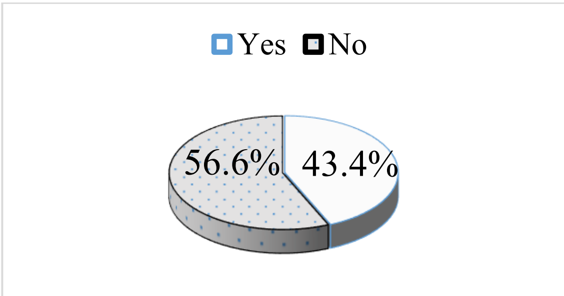


Figure 1. Percentage of workers using noise-reducing protective equipment.

The proportion of workers who used protective equipment to limit noise exposure is 43.4%, while the remaining 56.6% did not use protection.

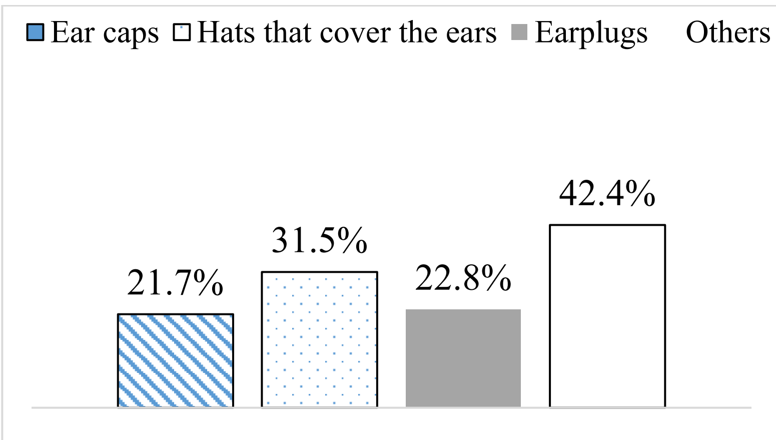


Figure 2. Common types of noise protection equipment (n=92)

In the group of workers using occupational safety equipment, 31.5% used hats with ear-covering brims, 22.8% used earplugs, and 21.7% used earmuffs; the remaining 42.4% used other types of protective equipment.

Table 2 Level of use of noise protection equipment (n=92)

| Usage level | n | % |
|---|---|---|
| Regularly | 43 | 46,7 |
| Occasionally | 49 | 53,3 |
| Total | 92 | 100,0 |

In the group of people using occupational safety equipment, 46.7% used it regularly, while the remaining 53.3% used it occasionally.

Table 3: Reasons for Not Using Noise Reduction Personal Protective Equipment Among Workers (n=120)

| Reason | n | % |
|---|---|---|
| Feel it is unnecessary | 61 | 50,8 |
| Feel it is cumbersome and inconvenient for work | 46 | 38,3 |
| Other | 13 | 10,8 |

***Comment*:** Among the group of workers not using protective equipment, the majority, at 50.8%, felt it was unnecessary. This was followed by 38.3% who found it cumbersome and inconvenient for work, and 10.8% cited other reasons.

Table 3.4: Factors Related to the Use of Noise Protection Equipment Among Workers

| **Factor** | **Use** | | **Not use** | | **p** |
|---|---|---|---|---|---|
| | **n** | **%** | **N** | **%** | |
| **Sex** | | | | | |
| *Men* | 22 | 28,9 | 54 | 71,1 | <0,05 |
| *Women* | 70 | 51,5 | 66 | 48,5 | |
| **Age** | | | | | |
| <18 | 2 | 66,7 | 1 | 33,3 | >0,05 |
| 18-60 | 80 | 42,1 | 110 | 57,9 | |

| | | | | | |
|---|---|---|---|---|---|
| >60 | 10 | 52,6 | 9 | 47,4 | |
| ***Working hours/day*** | | | | | |
| <8 hours | 2 | 100,0 | 0 | 0,0 | >0,05 |
| 8 hours | 13 | 31,7 | 28 | 68,3 | |
| >8 hours | 77 | 45,6 | 92 | 54,4 | |
| **Experience working at intersections** | | | | | |
| < 4 years | 71 | 44,7 | 88 | 55,3 | >0,05 |
| 4-10 years | 20 | 44,4 | 25 | 55,6 | |
| >10 years | 1 | 12,5 | 7 | 87,5 | |
| **Health examination** | | | | | |
| Yes | 51 | 53,1 | 45 | 46,9 | <0,05 |
| No | 41 | 35,3 | 75 | 64,7 | |
| **General noise level** | | | | | |
| ≥70dBA | 72 | 55,4 | 58 | 44,6 | <0,001 |
| <70 dBA | 20 | 24,4 | 62 | 75,6 | |

***Comment:*** The analysis shows that there is no correlation between gender, age group, or seniority and the use of noise protection equipment ($p > 0.05$). However, there is a correlation between regular health check-ups and the overall noise levels at intersections with the use of protective equipment. Specifically:- Among workers who participate in annual health check-ups, the rate of protective equipment use is 53.1%, which is higher than the 35.3% in the group that does not undergo regular check-ups, with a statistically significant difference ($p < 0.05$).

- In areas where noise levels are 70 dBA or higher, the rate of protective equipment use is 55.4%, compared to workers at intersections with noise levels below 70 dBA, showing a statistically significant difference ($p < 0.0001$).

Table 3.5: Some Physiological Signs Affected by Noise Among Workers

| Signs: | Quantity (n) | Percentage (%) |
|---|---|---|
| Headache | 77 | 36,3 |
| Forgetfulness | 76 | 35,8 |
| Insomnia | 52 | 24,5 |
| Difficulty concentrating | 51 | 24,1 |
| Poor hearing | 37 | 17,5 |
| Tinnitus (ringing in the ears) | 34 | 16,0 |
| Palpitations | 19 | 9,0 |

***Comment**: From the table, it can be observed that the percentage of workers experiencing headaches is the highest at 36.3%, followed by forgetfulness at 35.8%. Poor hearing accounts for 17.5%, and tinnitus (ringing in the ears) represents 16.0%.

## 4. Discussion

Nowadays, people are concerned about noise pollution. Noise affects our hearing and our health, and it also causes us to lose focus on our work, which reduces work efficiency. Devices such as earplugs, earmuffs, etc. are effective measures and remedies for workers to deal with the problem of noise pollution in everyday life and at the workplace. In noisy places, the use of occupational safety products and the implementation of appropriate preventive measures can minimize risks and prevent the harmful effects of noise as well as other work-related problems such as occupational accidents, etc. Our research shows that the percentage of workers 43.4% use protective measures and are equipped with devices that limit the effects of noise, while the remaining 56.6% do not take any protective measures. It is seen that freelancers are often exposed to job-related hazards such as dust, noise at intersections, intersections, etc. However, they are freelancers themselves and therefore do not follow any regulations or health and safety rules set by an organization such as a factory, a company or a company... but depend entirely on the consciousness of the workers. Our research results therefore show that the proportion of workers who do not take occupational health and safety measures to prevent the harmful effects of noise is quite high, up to 56.6%. To explain that ideals, freelancers gave a number of reasons why they had not taken protective measures in Table 3.3, 50.8% showed that employees thought it was unnecessary and 38.3% who thought it was inconvenient and inappropriate [4].

In the group of workers who wore occupational safety equipment, 31.5% used hats with brims to cover the ears, 22.8% used earplugs, and 21.7% used earmuffs; the remaining 42.4% used other types of protective equipment. There is no one-size-fits-all measure suitable for all workers, as it also depends on the noise level to which workers are exposed and workers' acceptance, comfort and convenience. According to the results of our research, the use of noise protection equipment is mostly simple, such as: hats with brims that can cover the ears, ... but there is no equipment that meets the standards. The results of our research show that 46.7% of the group of people who use occupational safety equipment use it regularly and the remaining 53.3% use it occasionally. Regular use of noise protection equipment goes a long way toward minimizing the effects of noise on workers' health. On the contrary, irregular use - occasional use or no use at all - is a factor that increases the possibility of negative effects of noise on the hearing system in particular and on the health of workers in general.

Our research results show that there was a relationship between periodic health examinations, the general level of negative pressure at intersections and the use of occupational health and safety measures, specifically: In the group of workers who participate in annual periodic health examinations, the rate of the use of occupational health and safety measures is is 53.1% higher than the group that does not seek regular health check-ups (35.3%), and the difference is statistically significant at $p < 0.05$. This is also understandable, since the majority of workers who have the habit and behavior of annual regular health examinations are people who are very concerned about protecting their health and therefore are usually always looking for measures and apply these measures to protect their health and eliminate harmful factors that may affect their health; At the same time, they are medically examined as part of regular annual health checks and receive advice and advice appropriate to them and their work to protect their health. The research results also show that the rate of use of occupational safety equipment in the group of workers in areas with a sound pressure level ≥ 70 dBA is 55.4% higher than in the group of workers at intersections with a sound pressure level below 70 dBA and the Difference is statistically significant with $p<0.0001$. Typically, noise levels of 50 dB or more cause discomfort to people exposed to noise. According to Vietnamese standards, noise in normal areas can be up to 70 dBA every day from 6 a.m. to 9 p.m. The main source of noise at traffic intersections is primarily the noise of vehicles participating in traffic; especially during rush hour.

According to the World Health Organization (WHO), the impact of noise on human health is second only to dust. Noise causes direct and indirect effects on human health, such as: hearing loss, high blood pressure, cardiovascular disease, neurological symptoms, etc. Road traffic noise is the most common source of environmental noise and contributes the most to the overall impact of noise on health [5]. In our study we also pointed out a number of functional signs related to the impact of noise on freelancers at intersections and junctions, in particular the proportion of workers with signs of headache is the highest (36.3%), followed by signs of forgetfulness 35.8%; Hearing loss in 17.5% and tinnitus in 16.0%. The relationship between traffic noise and health effects is very complex, in part due to the many factors involved and the magnitude of the direct and indirect health effects. According to a study by Nguyen Tai Dung (2022), the rate of functional symptoms due to noise exposure is highest for tinnitus at 78.41%, followed by dizziness at 60.95%, headache at 59.68% and hearing loss at 59.37 % [6]. According to research by Trinh Thi Giao Chi and Nguyen Thi Ngoc Ha (2012), road traffic noise causes various health effects on people such as headaches, insomnia, high blood pressure, hearing-related diseases... mainly headaches and insomnia with the respective rates of 44.4% and 38, 5%[7].

## 5. Conclusion

The percentage of workers using protective equipment to limit noise exposure is 43.4%, while the remaining 56.6% do not use any protection. Among those who do use protective gear, 31.5% use earmuffs with a full ear covering, 22.8% use earplugs, and 21.7% use ear caps. Within the group of workers using protective equipment, 46.7% use it regularly, while 53.3% use it occasionally. There is a correlation between regular health check-ups, the overall sound pressure levels at intersections, and the use of protective equipment ($p<0.05$ and $p<0.001$).

## 6. Recommendations

It is recommended to raise awareness among workers about the importance of using protective equipment to mitigate noise exposure, especially in areas with high sound pressure levels. Additionally, workers are encouraged to participate in annual health check-ups.

## References

1. Adarsh Yadav, Jyoti Mandhani, Manoranjan Parida et al. Modelling of traffic noise in the vicinity of urban road intersections. Transportation Research Part D: Transport and Environment, 112, 103474, (2022).
2. Vishal Konbattulwar, Nagendra R. Velaga, Saurav Jain et al. Development of in-vehicle noise prediction models for Mumbai Metropolitan Region, India. Journal of Traffic and Transportation Engineering, 3 (4), (2016).
3. WHO Europe. Environmental noise guidelines for the European region,(2018).
4. Soumyajit Das, Vinoth kumar Kalidoss and Satvinder S Bakshi. Noise levels at traffic intersections and awareness of noise pollution among traffic policemen and automobile drivers. International Journal of Occupational Safety and Health, 13 (3), 353-360, (2023).

5. European Enviroment Agency. Health impacts of exposure to noise from transport,(2022).
6. Nguyen Tai Dung. Current status of hearing loss, some related factors and preventive effectiveness of Mg-B6 supplementation in armored troops in 2017-2018, PhD Thesis, National Institute of Hygiene and Epidemiology, Ha Noi, (2022).
7. Trinh Thi Giao Chi and Nguyen Thi Ngoc Ha. Assessing the impact of noise from road traffic activities on people living along some roads in the south of Hue city. Hue University Journal of Science, Vol 73 (No 4), 19-28, (2012).

# Simultaneous Detection of Ascorbic Acid, Dopamine, and Uric Acid using electrophoretically deposited graphene sensor

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**Abstract:** We demonstrate electrophoretically deposited graphene sensor to simultaneously detect Ascorbic Acid, Dopamine, and Uric Acid. The proposed sensor exhibited excellent selectivity and sensitivity, and a wider linear range. The linear response of the sensor is 1 - 20 μM with a sensitivity of 5725.6 $\mu Acm^{-2}mM^{-1}$; and for UA, there were two linear ranges: 1 - 10 μM and 10 - 50 μM with corresponding sensitivities of 1001 $\mu Acm^{-2}mM^{-1}$ and 2438 $\mu Acm^{-2}mM^{-1}$, which provides a simple route for electrochemical sensors and biosensors in biochemical test.

*Keywords:* graphene, electrophoretically deposited, graphene-based electrochemical sensor.

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## 1. Introduction

Dopamine (DA) is one of the most important neurotransmitters which play vital role in the function of the central nervous, renal, hormonal and cardiovascular system. Low levels of DA may cause neurological disorders such as schizophrenia and Parkinson's disease. The rapid and accurate determination of DA concentration in body fluid is meaningful in diagnose [1]. However, uric acid (UA) and ascorbic acid (AA) usully coexist with DA in real biological samples. On the other hand, the abnormal level of UA may cause gout, hyperuricemia, Lesch-Nyan syndrome, cardiovascular disease and chronic renal disease [2]. AA is a form of C vitamin that is known to take part in several biological reactions [3]. Therefore, the development of a sensitive and selective method for their simultaneous determination is highly desirable for analytical applications and for diagnostic research [4].

Currently, various methodsare developed for determination of UA, DA and AA, such as high-performance liquid chromatography (HPLC), chemiluminescence, electrochemistry, etc. Among these methods, the electrochemical sensing has attracted many researchers because of its easy fabrication into a handheld device that can be used at home [5]. However, the sensing electrodes are susceptible to contamination or interference by biological macromolecules and electroactive substances coexisting from complex samples, resulting in low sensitivity and poor accuracy [6]. Therefore, using materials to improve electrodes plays an important role in developing sensors. Consequently, various materials, including metallic origin materials such as Pt [7], Al2O3 [8], MgO [9] [10], TiO2 [11], Au-SiO2 nanocomposites [12]; carbon derivative materials like graphene [13] [14] [15], carbon nanotubes [16] [17]; and graphene [15-17] have been applied for fabricating electrochemical sensor. Among them, graphene is one of the most promising candidate because of its inherent properties, such as nano-2D structure, excellent mechanical and electrical properties. Besides fabricating graphene material for the sensor, the electrode fabrication process plays a very important role in creating a stable electrode with high sensitivity and repeatability. However, the large 2D size is a challenge, especially using expensive methods such as chemical vapor deposition (CVD), molecular beam epitaxy (MBE) [10-12, 18]. Thus, it is pertinent to find graphene-based nonenzymatic sensor for simultaneous detection of Ascorbic Acid, Dopamine, and Uric Acid with high sensitivity, low detection limit, and cost-effective preparation.

In this study, we present the construction of a graphene-based electrochemical sensor for simultaneous detection of Ascorbic Acid, Dopamine, and Uric Acid. The obtained sensor exhibits excellent selectivity and sensitivity, and a wider linear range.

## 2. Experimental

### *2.1. Materials and reagents*

Indium tin oxide coated glass (ITO) (6-8 Ω $sq^{-1}$, 185 nm thick) from Biotain Crystal Co., Limited was used as a substrate for graphene deposition. Uric acid, ascorbic acid, dopamine, $NH_4NO_3$, KOH, $(NH_4)_2SO_4$, and graphite rode were purchased from Sigma-Aldrich.

### *2.2. Fabrication of graphene/ITO electrode*

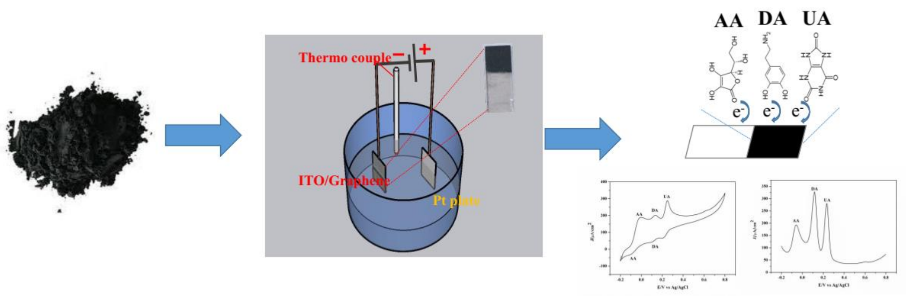


Fig. 1. Schematic scheme for fabricating of graphene-based electrochemical sensor

Graphene fabrication was performed by electrochemical exfoliation from the previous report [19]. To fabricate the graphene/ITO electrode, 100 mg of graphene was first dispersed in 50 mL of IPA solvent and several $Mg(NO_3)_2$ crystals. After the mixture was completely dispersed by ultrasonic vibration, two electrodes of the electrophoresis system were placed, in which the cathode was the Pt plate, the anode was the ITO substrate, the distance between the two electrodes was 2 cm. The electrode was then dried in an oven at 80 °C for 12 h before being used as a sensor.

Strucural characterization and electrochemical measurements

The structure and morphology of materials were characterized by scanning electron microscopy (SEM), Raman spectroscopy. The electrochemical studies were carried out by electrochemical workstation Autolab 302 N (version Nova 1.10) with modified graphene/ITO working electrode, Pt sheets counter electrode, and Ag/AgCl reference electrode (saturated 3 M KCl), and PBS (Phosphate-buffered saline; pH 7.4) aqueous electrolyte

## 3. Results and discussions

### *3.1. The morphology and structural characterzation of materials*

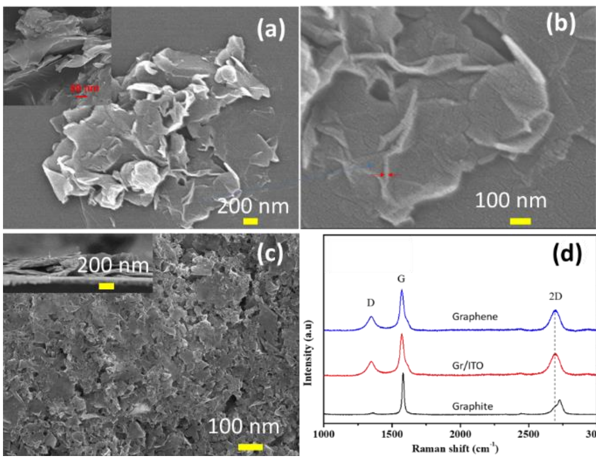


Fig. 2.. SEM images of (a) exfoliated graphene nanosheets; (b) electrophoretically deposited graphene/ITO; (c) cross-section of graphene/ITO, and (d) Raman spectrum of graphene/ITO

Raman spectroscopy is a fast and efficient tool to confirm graphene through the position and shape of the characteristic peaks as shown in Figure 3 (d). Normally, Raman spectra of graphite materials have characteristic peaks D with weak intensity around 1348 cm-1 (related to lattice defects), G peak with strong intensity (characteristic peak of lattice of graphite) at 1580cm$^{-1}$ and the 2D peak has an asymmetrical shape with weaker intensity around 2720 cm$^{-1}$. As shown in Fig 2, 2D peak changed markedly, it changed from asymmetric shape to symmetric shape accompanied by peak shift from 2725 cm$^{-1}$ to 2695cm$^{-1}$ corresponding to multilayer graphene [19,20]. This result confirms that graphene has been successfully fabricated, consistent with previous studies. In addition, after electrophoretic deposition of graphene on the ITO substrate, the position and shape of the characteristic peaks remained unchanged, showing that the electrophoresis method is very effective for constructing of a graphene-based electrochemical sensor or electrochemical measurements. Notably, SEM images clearly indicate the change from bulk form of graphite to thin layer graphene before and after the plasma assisted electrochemical exfoliating.

Electrochemical performance

Electrochemical property of the electrodes in $Fe(CN)_6^{3-/4-}$ solution

A solution containing equivalent concentrations of $K_3Fe(CN)_6$ and $K_4Fe(CN)_6$ is commonly used to evaluate the surface activity of the electrode. Figure 2.6 shows the CV curve of the Gr/ITO electrode and the "bare" ITO electrode in a solution containing both 1 mM $K_3Fe(CN)_6$ and 1 mM $K_4Fe(CN)_6$, and 0.1 M KCl. The CV curve exhibits an oxidation peak corresponding to the peak current density jpa in the positive scan direction, corresponding to the process:

$$Fe(CN)_6^{4-} \longrightarrow Fe(CN)_6^{3-} + e \qquad (1)$$

In contrast, in the negative scan, a reduction peak with peak current density $j_{pc}$ corresponds to the process:

$$Fe(CN)_6^{3-} + e \longrightarrow Fe(CN)_6^{4-} \qquad (2)$$

Figure 3(a) shows that the potentials of the processes on the ITO and Gr/ITO electrodes are equivalent, indicative of the redox couple Fe(CN)63-/Fe(CN)64-. However, the current density of the redox peaks on the Gr/ITO electrode is significantly higher than that on the ITO electrode. This confirms that the surface of the Gr/ITO electrode exhibits a stronger electrocatalytic ability compared to the ITO electrode, thus demonstrating the role of graphene as an electrocatalyst modifier

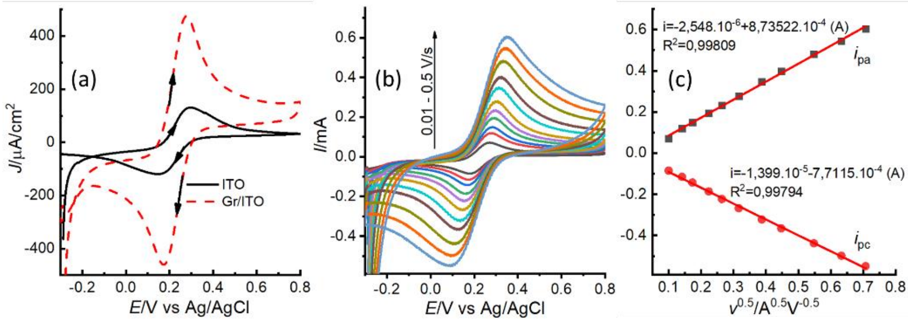


Fig. 3. (a) Cyclic voltammogram (CV) of ITO and Gr/ITO in 1 mM $Fe(CN)_6^{3-/4-}$; (b) CV of Gr/ITO with different scan rate; (c) the dependence of oxidation/reduction peaks on root of scan rate

To assess the electrocatalytic activity of the electrode, the CV technique at different scan rates for the Gr/ITO electrode was investigated as shown in Figure 3(b), and the peak current density as a function of the square root of the scan rate was plotted in Figure 3(c). The electrochemically active surface area of the Gr/ITO electrode is determined using the Randles-Sevcik equation:

$$i_{pa} = 2.69 \times 10^5 n^{1,5} A D_{Red}^{0,5} C_{Red} v^{0,5} \quad (3)$$

$$i_{pc} = 2.69 \times 10^5 n^{1,5} A D_{Ox}^{0,5} C_{ox} v^{0,5} \quad (4)$$

where and are the anodic and cathodic peak currents, respectively. *n* represents the number of electrons exchanged in the redox couple. $D_{Red}$ and $C_{Red}$ are the diffusion coefficient and concentration of the reduced form of $Fe(CN)_6^{4-}$, respectively. $D_{Ox}$ and $C_{Ox}$ are the diffusion coefficient and concentration of the oxidized form of $Fe(CN)_6^{3-}$, respectively.

From the CV curve shown in Figure 3(b), the dependence of the anodic and cathodic peak currents on the root of scan rate is obtained in Figure 3(c). From the slope values of the linear lines, the electrochemically active surface area (A) can be determined. Here, the number of electrons exchanged (n) is equal to 1. The diffusion coefficients in 0.1 M KCl are $D_{Red}$ = 7.39 x $10^{-6}$ (cm/s) and $D_{Ox}$ = 6.43 x $10^{-6}$ (cm/s), which have been referenced from the literature [18]. The results obtained from the oxidation and reduction peak give similar values for the electrochemically active surface area (A). An approximate value for this area is obtained by taking the average of the two calculated values, which is 1.163 $cm^2$. Compared to the actual surface area of the electrode, which is 0.25 $cm^2$, this value is approximately 4.65 times larger, indicating the good electrochemical activity of the Gr/ITO electrode.

### *3.2. Electrochemical of Gr/ITO to AA, DA and UA*

The CV technique of the electrode was performed in a phosphate-buffered saline (PBS) solution at pH 7.4, containing AA, DA, and UA at concentrations of 500 µM, 50 µM, and 100 µM, respectively, using a scan rate of 20 mV/s within the potential range from -0.3 V to 0.8 V. In order to compare the electrocatalytic activity of Gr on the ITO substrate with that without Gr, we conducted a study on the characteristics of these two electrodes under the same conditions. The results indicate that there is virtually no response of AA, DA, and UA at the bare ITO electrode (Figure 4(a)), while the characteristic oxidation peaks of AA (0.032 V), DA (0.1874 V), and UA (0.3197) V are clearly observed (Figure 4(b)), with a distinct reduction peak for DA (0.1337 V). Figure 4(c) shows the DPV curve of the Gr/ITO electrode for AA (-0.0325 V), DA (0.185 V), and UA (0.3175 V) with well-defined and separated peaks. Therefore, the Gr/ITO electrode has the capability to simultaneously determine AA, DA, and UA.

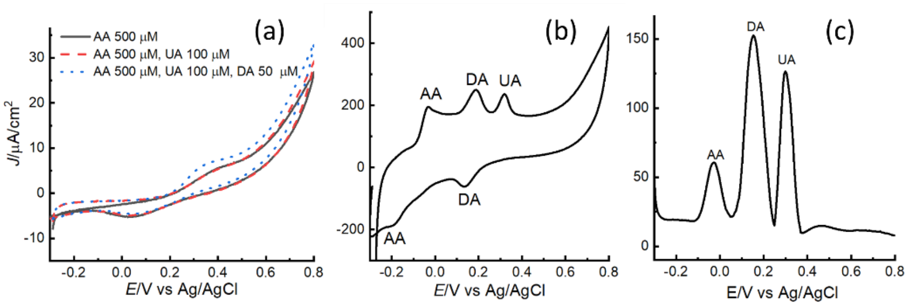


Fig. 4. CV curve of (a) ITO; (b) Gr/ITO and (c) DPV curve of Gr/ITO in

PBS pH 7.4 containing of 500 µM AA, 50 µM DA and 100 µM UA

### *3.3. Simultaneous determination of AA, DA, and UA*

The study involves the simultaneous determination of AA, DA, and UA by measuring the DPV curves of one compound while keeping the concentrations of the other two compounds constant, as illustrated in Figure 5 (a, b, c), respectively. The plot illustrates the peak oxidation current density of AA, DA, and UA as a function of their respective concentrations, as shown in Figure 5 (d, e, f). From this, the linear range, sensitivity, and limit of detection of the sensor are determined. The results showed that for AA, the linear range was 50 - 700 µM with a sensitivity of 32.95 $\mu Acm^{-2}mM^{-1}$; for DA, the linear range was 1 - 20 µM with a sensitivity of 5725.6 $\mu Acm^{-2}mM^{-1}$; and for UA, there were two linear ranges: 1 - 10 µM and 10 - 50 µM with corresponding sensitivities of 1001 $\mu Acm^{-2}mM^{-1}$ and 2438 $\mu Acm^{-2}mM^{-1}$.

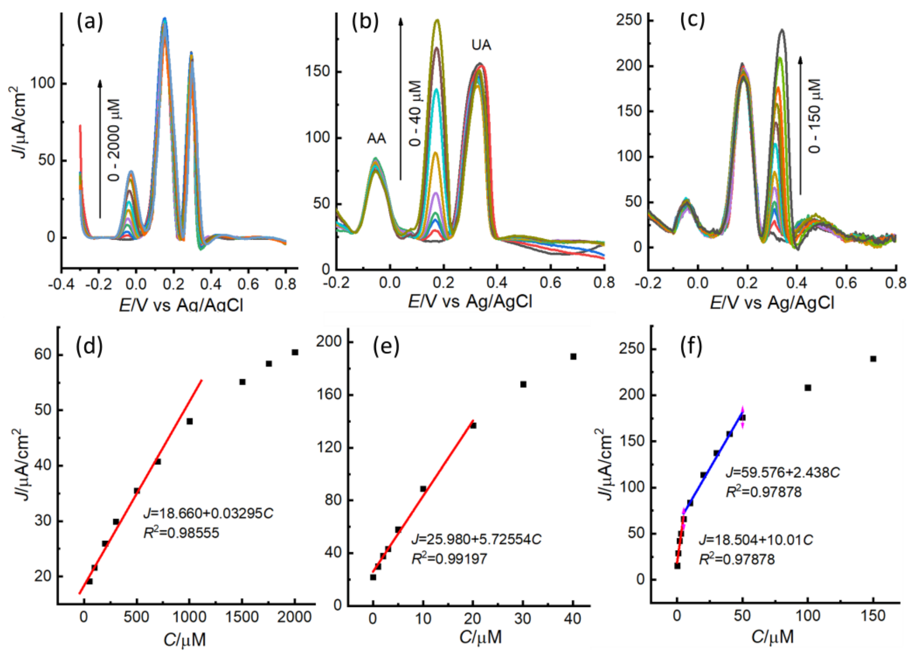


Fig. 5. (a, b, c) DPV curve of Gr/ITO of AA, DA, and UA in the presence of

2 remain subtances (30 μM DA; 30 μM UA); (2 mM AA; 50 μM DA); (1 mM AA; 50 μM DA), respectively; (d, e, f) plot of peak current density vs concentration of AA, DA, and UA, respectively.

## 4. Conclusion

An electrochemical sensor based electrophoretically deposited graphene/ITO electrode was employed for simultaneous detection of UA, DA and AA in PBS buffer pH 7.4. The results showed that for AA, the linear range was 50 - 700 μM with a sensitivity of 32.95 $\mu Acm^{-2}mM^{-1}$; for DA, the linear range was 1 - 20 μM with a sensitivity of 5725.6 $\mu Acm^{-2}mM^{-1}$; and for UA, there were two linear ranges: 1 - 10 μM and 10 - 50 μM with corresponding sensitivities of 1001 $\mu Acm^{-2}mM^{-1}$ and 2438 $\mu Acm^{-2}mM^{-1}$. Thus, this work could provide a simple route method for the electrochemical sensing AA, DA and UA in biochemical test.

## References

1. Wightman, R. M., May L. J., Michael A. C.: Detection of dopamine dynamics in the brain. Analytical chemistry 60(13), 769A-93A (1988)
2. Grabowska, I., Chudy M., Dybko A., Brzozka Z.: Uric acid determination in a miniaturized flow system with dual optical detection. Sensors and Actuators B: Chemical 130(1), 508-13 (2008)
3. Liu, A., Wei M. D., Honma I., Zhou H.: Biosensing properties of titanatenanotube films: Selective detection of dopamine in the presence of ascorbate and uric acid. Advanced Functional Materials 16(3), 371-6 (2006)
4. Li, Y., Lin X.: Simultaneous electroanalysis of dopamine, ascorbic acid and uric acid by poly (vinyl alcohol) covalently modified glassy carbon electrode. Sensors and Actuators B: Chemical 115(1), 134-9 (2006)
5. Li, M., Guo W., Li H., Dai W., Yang B.: Electrochemical biosensor based on one-dimensional MgO nanostructures for the simultaneous determination of ascorbic acid, dopamine, and uric acid. Sensors and Actuators B: Chemical 204, 629-36 (2014)
6. Zheng, J., Zhu M., Kong J., Li Z., Jiang J., Xi Y., Li F.: Microfluidic paper-based analytical device by using Pt nanoparticles as highly active peroxidase mimic for simultaneous detection of glucose and uric acid with use

of a smartphone. Talanta 237, 122954 (2022)

7. Soltani, N., Ebrahimian J., Khayatkashani M., Tavakkoli N., Salavati-Niasari M.: Salvia officinalis extract mediated for the synthesis of SO-MgO-NPs and their utilization for simultaneous measurement of dopamine, uric acid, and ascorbic acid by voltammetry method. Journal of Molecular Liquids 341, 116932 (2021)
8. Mahshid, S., Li C., Mahshid S. S., Askari M., Dolati A., Yang L., Luo S., Cai Q.: Sensitive determination of dopamine in the presence of uric acid and ascorbic acid using TiO2 nanotubes modified with Pd, Pt and Au nanoparticles. Analyst 136(11), 2322-9 (2011)
9. Immanuel, S., Aparna T., Sivasubramanian R.: A facile preparation of Au—SiO2 nanocomposite for simultaneous electrochemical detection of dopamine and uric acid. Surfaces and Interfaces 14, 82-91 (2019)
10. Ma, T., Meng J., Song Q., Wen D.: Superhydrophilic edge-rich graphene for the simultaneous and disposable sensing of dopamine, ascorbic acid, and uric acid. Journal of Materials Chemistry B 10(7), 1094-102 (2022)
11. Feng, S., Yu L., Yan M., Ye J., Huang J., Yang X.: Holey nitrogen-doped graphene aerogel for simultaneously electrochemical determination of ascorbic acid, dopamine and uric acid. Talanta 224, 121851 (2021)
12. Zhang, H., Liu S.: Electrochemical sensors based on nitrogen-doped reduced graphene oxide for the simultaneous detection of ascorbic acid, dopamine and uric acid. Journal of Alloys and Compounds 842, 155873 (2020)
13. Zhao, Y., Yang Z., Fan W., Wang Y., Li G., Cong H., Yuan H.: Carbon nanotube/carbon fiber electrodes via chemical vapor deposition for simultaneous determination of ascorbic acid, dopamine and uric acid. Arabian Journal of Chemistry 13(1), 3266-75 (2020)
14. Yang, M., Wang H., Liu P., Cheng J.: A 3D electrochemical biosensor based on Super-Aligned Carbon NanoTube array for point-of-care uric acid monitoring. Biosensors and Bioelectronics 179, 113082 (2021)
15. Wang, M., Guo H., Wu N., Zhang J., Zhang T., Liu B., Pan Z., Peng L., Yang W.: A novel triazine-based covalent organic framework combined with AuNPs and reduced graphene oxide as an electrochemical sensing platform for the simultaneous detection of uric acid, dopamine and ascorbic acid.

Colloids and Surfaces A: Physicochemical and Engineering Aspects 634, 127928 (2022)

16. Beduk, T., de Oliveira Filho J. I., Ait Lahcen A., Mani V., Salama K. N.: Inherent Surface activation of laser-scribed graphene decorated with au and ag nanoparticles: Simultaneous electrochemical behavior toward uric acid and dopamine. Langmuir 37(47), 13890-902 (2021)
17. Mazzara, F., Patella B., Aiello G., O'Riordan A., Torino C., Vilasi A., Inguanta R.: Electrochemical detection of uric acid and ascorbic acid using r-GO/NPs based sensors. Electrochimica Acta 388, 138652 (2021)
18. Konopka, S., McDuffie B.: Diffusion coefficients of ferri- and ferrocyanide ions in aqueous media, using twin-electrode thin-layer electrochemistry. Analytical Chemistry 42(14), 1741-6 (1970).
19. P.W. Johnson, J. Ibbotson-Brown, S. Menocal, J. Parison, Comparison of Whole Body Vibration Exposures When Operating a City Bus with and Active, Passive and Static Suspension Bus Seat, Proceedings of the Human Factors and Ergonomics Society 63 (2019) 1051-1055. https://doi.org/10.1177/10711 81319631472.
20. H.W. Davies, F. Wang, B.B. Du, R. Viventi, P.W. Johnson, Exposure to Whole-Body Vibration in Commercial Heavy-Truck Driving in On- and Off Road Conditions: Effect of Seat Choice, Annals of Work Exposure and Health 66 (2022) 69-78.
21. N. Raffler, J. Rissler, R. Ellegast, C. Schikowsky, T. Kraus, E. Ochsmann, Combined exposures of whole-body vibration and awkward posture: a cross sectional investigation among occupational drivrs by means of simultaneous field measurements, Ergonomics 60 (2017) 1564-1575. https://doi.org/10.1080/00140 139.2017.1314554
22. M.M. Jelicic, M. Milosevic, N.Prelenda. Analysis of Phyysical Activity as a Mediator between non-Ergonomic Position of Upper Body Segments and Musculoskeletal Health in Bus Drivers. Kinesiology 54 (2022) 249-255
23. M.A. Zulkarnain, Y. Setyaningsih, I. Wahyni, Personal characteristic, occupational, work environment and Psychosocial stressor factors of musculoskeletal disorders (MSDs

# Study on the level of exposure to radioactive radon gas ($^{222}$Rn; $^{220}$Rn) on the people's health in the Sin Quyen copper mine area, Lao Cai

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**Abstract:** Radon and its isotopes are inert gases, they do not participate in any chemical compounds. Compared to thoron (Rn-220) and radon-219, the risk of radiation exposure of radon-222 is high due to its long half-life of 3.8 days, the half-life of thoron is 55 seconds and that of Rn-219 is 4 seconds. As a gas, radon can escape from the surface of ore minerals, rocks and can move far from the location of formation. The article determined the concentration of radon gas ($^{222}$Rn; $^{220}$Rn) in the air to assess the level of exposure to radioactive radon gas for people in the Sin Quyen copper mine area, Lao Cai.

The results of the assessment of the average annual exposure of workers in the working positions at the mine showed that the exposure was in the range of 0.062÷0.828 WLM/y. This exposure level is relatively safe for the health of workers, however, if considered in the context of long-term exposure, it is necessary to consider measures to minimize the effects of radioactive radon gas ($^{222}$Rn; $^{220}$Rn) on workers working at the copper mine.

*Keywords*: Rn-222, Rn-220, radon exposure, radon risk, cancer

## 1. Introduction

In recent years, along with socio-economic development, many environmental problems have arisen, including the problem of radioactive environment related to mineral exploitation activities. In particular, radioactive gas radon

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($^{222}Rn$; $^{220}Rn$) from mining activities can cause serious impacts on the environment and human health [1-4].

Radon gas is present in most places in the earth's crust, escaping from soil and rocks through cracks, holes, faults, underground water veins into the air by diffusion and convection. Radon exists in high concentrations in areas of radioactive mineral mines, radioactive minerals, mines, in houses, especially in closed rooms such as bedrooms, offices; and in construction materials. This is a type of gas that international organizations such as the American Lung Association and the US Environmental Protection Agency (EPA) have classified as a carcinogen with effects on human health.

The main hazard of radioactive radon gas to health is the exposure of alpha radiation during the process of breathing and eating. Radon has also been identified as being related to many deaths from lung cancer and is suspected to be related to some other types of cancer such as leukemia, malignant tumors, kidney cancer and some childhood cancers. Epidemiological investigations and studies show that radon can penetrate the body, dissolve in fat cells and blood in the same way that oxygen enters the blood [5-9]; as a result, it accumulates in fat cells of the bone marrow; In other words, radon enters the human body like plants absorb sunlight silently and leaves unpredictable consequences [10, 11]. Among cancers, lung cancer is considered the most dangerous because the number of deaths is among the highest [10].

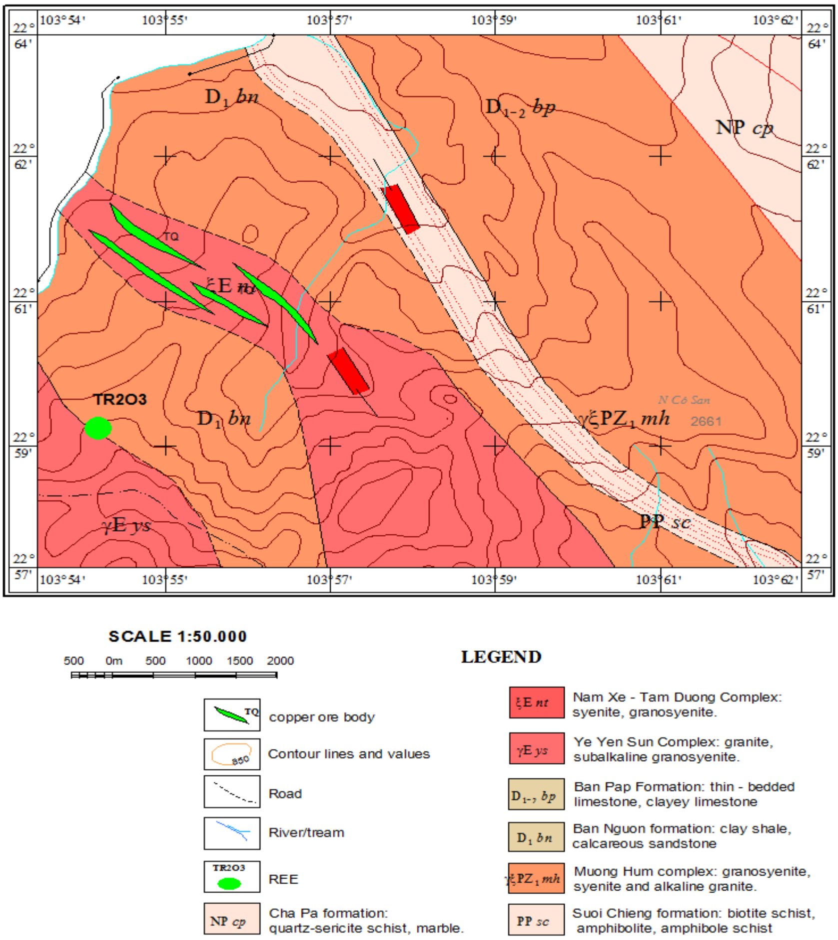
Radon exposure does not cause acute illness, irritation, or early warning signs compared to other common environmental risks. However, concentrated radon exposure increases the risk of lung cancer, especially in smokers. This risk increases with the radon concentration, the length of exposure, and the amount of tobacco smoked [10, 11].

Some studies have shown that radon is a related cause of leukemia, skin cancer, melanoma, kidney cancer in children, and some other cancers. These studies are based on statistical analyses of indoor radon and the range of cancer effects [11]. The main harm caused by chronic exposure to radon is lung cancer (usually arising from the bronchi), including: pulmonary fibrosis, chronic obstructive pulmonary disease, pneumoconiosis, respiratory damage.

The paper presents the results of a survey on radon gas concentration and an assessment of radon exposure risks for residents and workers living and working at the Sin Quyen copper mine, Lao Cai.

## 2. Geological and mineral characteristics of the study area

Sin Quyen copper mine is located in Bat Xat district, Lao Cai province, with geographical coordinates of $22^{0}$37'20" North latitude, $103^{0}$45'50" East longitude. The ore area is located on the northeastern slope of Hoang Lien Son mountain range in Lao Cai province, on the right bank of the Red River, right next to the Vietnam - China border, 1-3 km from the Red River and 25 km southeast of Lao Cai. The mountainous terrain extends from the Northwest to the Southeast. Geological features of the area include the Suoi Chieng formation (PPsc), Sin Quyen formation (PP-MPsq), Ban Nguan formation ($D_1$bn), Cha Pa formation (NPcp), Ban Pap formation ($D_{1-2}$bp) (Figure 1). The copper content in this ore type ranges from 0.1 to 4.7%; the rare earth content is < 1%. In primary copper ore, radioactive elements such as uranium, thorium... $U_3O_8$ content reaches 0.005□0.265%; $ThO_2$ content reaches 0.006□0.03% [15, 16].




Figue 1. Geological and mineral map of the survey area [16].

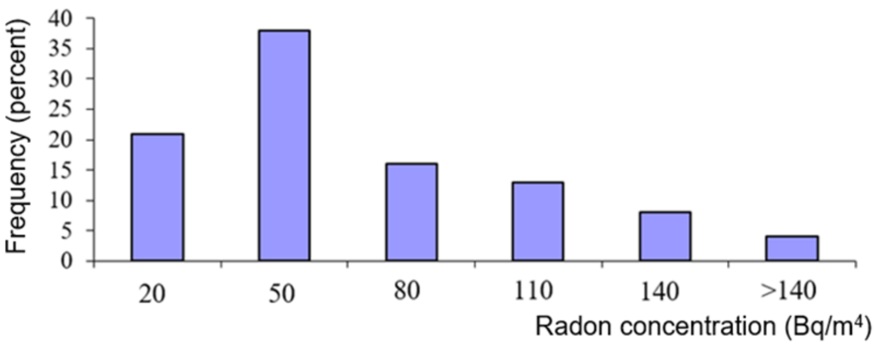



Figure 2. Radon concentration distribution graph of Sin Quyen copper mine

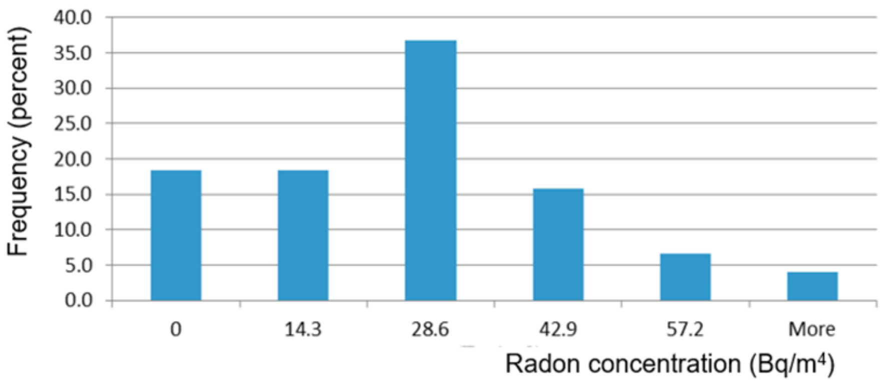



Figure 3. Radioactive gas concentration for residential houses

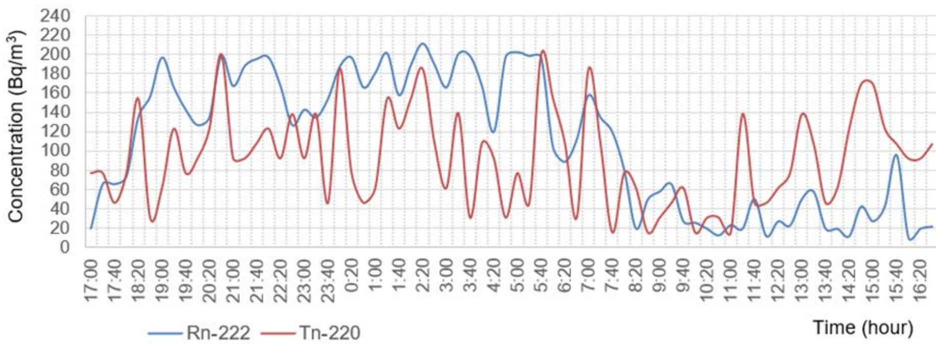



Figure 4. Radon gas monitoring by day and night

Table 2. Results of radon exposure assessment

| Position \ Exposure | Bq/m³ | pCi/l | WL | WLM/y |
|---|---|---|---|---|
| Mining area | 431 | 11.64 | 0.116 | 0.828 |
| Workshop area | 136 | 3.67 | 0.037 | 0.254 |
| residential area | 28.6 | 0.95 | 0.009 | 0.062 |

## 3. Research method

### *3.1. Survey of radon gas concentration in the research area*

Survey of radon concentration in the air in the research area, to assess the spatial distribution of radon at the Sin Quyen copper mine and neighboring residential areas.

From there, determine the internal dose level caused by radioactive radon gas according to the following formula [17-19]:

$H_t$(mSv.year$^{-1}$)=0.047×$C_{Rn}$(Bq.m$^{-3}$) (1)

where Ht is the internal radiation dose caused by radon in the air and $C_{Rn}$(Bq.m$^{-3}$) is the concentration of radon in the air.

### *3.2. Calculating cumulative radon exposure*

Accumulated exposures are defined as all activity levels (WL) multiplied by the exposure time. In the exposure assessments, this cumulative exposure is calculated by exposure for 1 month (or 170 working hours) [10, 20, 21]. Cumulative exposure is calculated using the following formula [10]:

, (2)

where WLM is cumulative exposure; $(WL)_i$ is the average concentration of radon and offspring during exposure; and $t_i$ is the total exposure time with 1 WL = $C_{Rn}$(Bq.m$^{-3}$)×0.00027.

The above formula is used for calculating cumulative exposures over time intervals with concentrations corresponding to those time periods. However, due to the limitations of research time and statistical data systems over a short time period, this article only intends to show the general method and calculation of the assessments for radon exposure in workers in different positions [10].

Average exposure rate value is estimated for one year:

×××, (3)

where EX is the average exposure rate estimated in a year (WLy)$^{-1}$; C is the average radon concentration (pCi.l$^{-1}$ or Bq.m$^{-3}$); F is the coefficient of balance between radon and its products, e.g., F=0.6 in the mine.

At a concentration of 1 pCi.l$^{-1}$, the exposure to offspring is calculated by:

EX = 1pCil$^{-1}$[0.6×0.01WL (pCil$^{-1}$)$^{-1}$]×[12 WLM(WLy)$^{-1}$] = 0.072 WLM/y. (4)

At a concentration of 1 Bq.m$^{-3}$, the exposure of descendants of radon is calculated by the formula:

EX=1Bq.m$^{-3}$[0.6×0.00027WL (Bq.m$^{-3}$)$^{-1}$]×[12WLM(WLy)$^{-1}$]= 0.00194 WML/y (5)

### *3.3. Assessing health risks due to radon exposure for officials and workers working at Sin Quyen copper mine*

To assess the risk of radon exposure for officials and workers at the Sin Quyen copper mine, the authors used the risk calculation model under the guidance of EPA (2009) to use a single model instead of 2 models like BEIR VI (NAS) [10] because the two previously proposed models almost all depend on the age and time of exposure. EPA uses a concentration model for risk calculations because a concentration model can assess the health effects of exposure at levels that change over time.

In BEIR VI, the risk/WLM is $6.52\times10^{-4}$ for the concentration model and is $4.43\times10^{-4}$ for the time period model. The EPA has calculated the concentration model so that the risk/WLM will be equal to the geometric significance of these two values, i.e., $5.38\times10^{-4}$. The risk factor according to the concentration model is $\beta=0.0768\times(4.43/6.52)^{0.5}=0.0634$, and the risk/WLM is $5.38\times10^{-4} \approx (6.52\times10^{-4})\times(4.43/6.52)^{0.5}$[10].

The concentration model indicates that the relative risk of excess exposure depends on the time the exposure was initiated, the age reached, and the rate of exposure (concentration) as follows [10]:

$$ERR = \beta\times(w_{5\text{-}14} + \theta_{15\text{-}24}\times w_{15\text{-}24} + \theta_{25+}\times w_{25+})\times\phi_{age}\times y_z \quad (6)$$

where ERR is an assessment of the level of risk; β is the risk factor; $w_{5\text{-}14}$, $w_{15\text{-}24}$, $w_{25+}$ are exposure at ages 5-14; 15-24, and 25 years or more, respectively; $\theta_{5\text{-}14}$; $\theta_{15\text{-}24}$; $\theta_{25+}$ are the risk that is relatively dependent on the time the exposure is initiated; $\phi_{age}$ describes the dependence on the age achieved; for mine workers and for retired people at 55 years old, $\phi_{age}=1.0$ and with retirement age of 60, $\phi_{age}=0.57$; $y_z$ is the classification from 1 for exposure < 0.5WL to 0.11 for exposure > 15WL, which describes the exposure speed dependence. For this calculation, since all WL values are < 0.5, $y_z= 1$.

Setting $\beta^* = \beta\phi_{age}$ and using the parameters shown in Table 1, the authors estimate the parameters for the risk model [10] with the following equation for calculating the excess relative risk:

$$ERR = \beta^{*}\times(w_{5\text{-}14} + 0.778w_{15\text{-}24} + 0.51w_{25+})\times\phi_{age}, \quad (7)$$

where $\beta^{*}$=0.0768 for age x< 55 y; $\beta^{*}$= 0.0438 for age 55 y ≤ x < 65 y; $\beta^{*}$=0.0223 for age 65 y≤ x< 75 y; and $\beta^{*}$=0.0069 for age x ≥75 y.

Table 1. Estimated parameters for concentration model [10]

| Concentration model (β×100=7.68) | |
|---|---|
| Time of exposure | $\theta_{15\text{-}24}$=0.78 |
| | $\theta_{25+}$=0.51 |
| Where $\beta^{*}$ | 0.0768 for x<55 y |
| | 0.0438 for 55 y≤x<65 y |
| | 0.0223 for 65 y≤x<75 y |
| | 0.0069 for x ≥75 y |

**4. Results and discussion**

***4.1. Characteristics of radon concentration in air***

The results of the survey document processing show that the concentration of radon in air ranges from 15 to 240 Bq/m$^3$, with a maximum value of up to 300 Bq/m$^3$ (Figure 2).

The area with high radon concentration is mainly concentrated in the mining area where copper ore is being exploited and in some boreholes used for blasting. This is the area where people work in the mine area, with an average radon concentration of 46.7 Bq/m$^3$.

***4.2. Characteristics of radon concentration in the surrounding residential area***

The concentration of radon in the surveyed residential area is shown in Figure 3.

Figure 3 shows that the radon gas concentration value in neighboring residential areas ranges from 8.7 to 135 Bq/m$^3$, with an average of 28.6 Bq/m$^3$, within the permissible limit compared to the world average indoor radon concentration (37 Bq/m$^3$) as recommended by UNSCEAR [22].

### *4.3. Results of monitoring radon gas concentration by day and night*

The author has monitored the change in radon gas concentration by day and night in the mine and residential areas. At the monitoring point, continuous measurements are conducted for 24 hours a day, recording data every 20 minutes, using a RAD-7 device. The monitoring results are shown in Figure 4.

From Figure 4, shows that:

- *Radon($^{222}Rn$) gas concentration:* the day-night variation of Rn-222 concentration, fluctuates between 25 and 170 Bq/m$^3$, the highest is up to 211 Bq/m$^3$. The highest is from 8:00 pm. to 9:00 am., the lowest is from 10:00 am. to 6:00 pm.

- *Thoron($^{220}Rn$) gas concentration:* the variation is different from the rule of Rn-220, high at noon and gradually decreases at night, fluctuates between 40 and 180 Bq/m$^3$, with an average value of about 70 Bq/m$^3$, the highest amplitude reaches 205 Bq/m$^3$ at 10:00 am. during the day.

### *4.4. Assessment of radon exposure in the study area*

From the results of the survey of radon ($^{222}$Rn) concentration in the study area, the study assessed the radon exposure level in the mining area and the surrounding residential area. The results are presented in Table 2.

The results of the average annual exposure assessment of workers in the mine and the surrounding residential area showed that the exposure was in the range of 0.062 ÷ 0.828 WLM/y. This exposure level is relatively safe for the health of workers and residents, however, if considered in terms of long-term exposure, it is necessary to consider and assess the impact of radon ($^{222}$Rn) in the study area.

### *4.5. Radon exposure risk assessment*

The results of the risk estimates for workers at the Sin Quyen copper mine are presented in Table 3.

Table 3. Estimation of risks at job locations at Sin Quyen copper mine

| Relatively risk / Position | EER (%) | WLM/y |
|---|---|---|
| Field workers | 147 | 0.828 |
| Classification worker | 119 | 0.711 |
| Workers loading and transporting vehicles | 117 | 0.651 |
| Workers in the disposal area | 35.2 | 0.181 |
| Workshop workers | 42.6 | 0.254 |
| Office staff | 0.68 | 0.828 |

Table 3 shows that the above model is applicable to risk calculations with long periods of time and different stages are carefully observed for radon concentration and exposure in each stage. However, due to the conditions and the measurement of exposure was conducted in a short period of time, the author only determined the health risks for some working positions under exposure conditions at an average measured concentration.

## 5. Conclusion

The article has determined the characteristics of radon gas concentration ($^{222}Rn$; $^{220}Rn$) in the air in the Sin Quyen copper mine area and neighboring residential areas, in order to assess the level of exposure to radon radioactive gas and protect public health.

The results of the assessment of the average annual exposure of workers in the mine's working positions and neighboring residential areas show that the exposure is in the range of 0.062 ÷ 0.828 WLM/y. This exposure level is relatively safe for the health of workers and residents, however, if considered in long-term exposure conditions, it is necessary to consider and evaluate the impact of radon radioactive gas ($^{222}Rn$) in the study area.

To assess the impact of radioactive radon gas ($^{222}Rn$; $^{220}Rn$) on the study area, it is necessary to have programs to investigate sociology, environmental health and the impact of radiation on human health in the mining area to have a basis for a full, comprehensive and accurate assessment of the rate of radiation-related diseases, especially the impact of radon gas. From there, there will be specific solutions to minimize the impact of radiation in mineral exploitation and processing activities in the mine, and have reasonable policies in planning residential areas and using land and water resources in the area.

## References


1. M. Antonopoulos-Domis, S. Xanthos, A. Clouvas, D. Alifrangis, "Experimental and theoretical study of radon distribution in soil," Health physics, vol. 97, pp. 322-331, 2009.
2. G. Akerblom, P. Andersson, B. Clevensjo (1984), "Soil Gas Radon - A Source for Indoor Radon Daughters," Radiation Protection Dosimetry, vol. 7, pp. 49-54, 1984.
3. G. Imme, R. Catalano, G. Mangano, D. Morelli, "Radon exhalation measurements for environmental and geophysics study," Radiation Physics and Chemistry, vol. 95, pp. 349- 351, 2012.
4. Ishimori, K. Lange, P. Martin, Y.S. Mayya, M. Phaneuf. (2013). Measurement and Calculation of Radon Releases from NORM Residues. Technical Reports Series.
5. IAEA (2003). Extent of environmental contamination by naturally occurring radioactive material (NORM) and technological options for mitigation. IAEA, Vienna Derin MT, Vijayagopal P, Venkatraman B, Chaubey RC, Gopi-nathan A (2012) Radionuclides and radiation indices of high background radiation area in Chavara-Neendakara placer deposits (Kerala, India). PLoS One 7(11):e50468. doi:10.1371/journal. pone.0050468.
6. IAEA (2003). Radiation Protection against Radon in Workplaces other than Mines, Safety Reports Series No.33, Vienna.
7. ICRP (2009). International Commission on Radiological Protection Statement on Radon, ICRP Ref 00/902/09.
8. WHO Regional Office for Europe (2009). Radon levels in Dwellings, Fact sheet 4.6, Code: RPG4_Rad_Ex1,

European Environment and Health Informatinon System.

9. Naturally-Occurring Radioactive Materials (NORM), World Nuclear Association. http://www.world-nuclear.org/info/Safety-and-Security/Radiation-and-Health/Naturally-Occurring-Radioactive-Materials-NORM/. Assessed 02 Aug 2014.

10. Environmental Protection Agency (2003). EPA Assessment of Risks from Radon in Homes EPA 402-R-03-003. Office of Radiation and Indoor Air, United States Environmental Protection Agency - Washington, DC.

11. National Academy of Sciences (1994). Health Effects of Exposure to Radon: Time for Reassessment. National Academy Press, Washington, DC.

12. C.A. Papachristodoulou, D.L. Patiris, K.G. Ioannides (2010). "Exposure to indoor radon and natural gamma radiation in public workplaces in north-western Greece", Radiation Measurements, doi:10.1016/j.radmeas.2010.02.018. (article in press).

13. Ministry of Trade and Industry (2011). "The detailed plan for exploration, mining, processing and use of radioactive ores for the period to 2020, with a vision to 2030 ". Department of Geology and Minerals Vietnam, Hanoi.

14. Phuong N, Dung NV, Phon LK, Dong NP, Anh VTL, Huan TD, Chau TL, Hai DV (2013). A study on the increase of natural radiation field due to the exploration of rare earth ores in the Dong Pao and Nam Xe areas - Lai Chau Province. J Geol A 335: 56-62 (in Vietnamese with abstract in English). http://idm.gov.vn/Data/TapChi/2013/A335/a62.htm. Assessed 16 Oct 2014.

15. Trong Tran Binh, Huan Trinh Đinh, Nguyen Phuong (2007). "Investigating the current state of radioactive environment on the deposits of Dong Pao, Then Sin-Tam Duong (Lai Chau), Muong Hum (Lao Cai), Yen Phu (Yen Bai), Thanh Son (Phu Tho), An Diem, Ngoc Kinh-Suon Giua (Quang Nam)", Geological Magazine, Series A (298), p.41-47, Hanoi.

16. Le Quoc Trung et al (2008). Exploration proposal to upgrade reserves and exploration in 2007 and 2008 during the period Sin Quyen copper mine production - Lao Cai month 04/2005, the Company recruited Sin Quyen copper mine - Lao Cai.

17. Ministry of Science and Technology (2012). Circular "Provisions on control and ensure the safety of irradiated and irradiated career public", No.19/2012/TT-BKHCN,

Hanoi.

18. Investigation and evaluation of geological environment of radioactive gas method. Vietnam Standards 9416:2012, 2012.
19. UNSCEAR (2006). Annex E. Sources to effects assessment for Rn in homes and workplaces. United Nations Scientific Committee on the Effects of Atomic Radiation, New York, 2006.
20. EPA (2009). A Citizens Guide to Radon. United States Environmental Protection Agency, Washington DC (2009).
21. National Research Council (1999). Health Effects of Exposure to Radon: BEIR VI. Washington, DC: The National Academies Press.
22. UNSCEAR, 2000 (Scientific A nnex B).
23. ANNEX A: Dose assesment methodologies
24. ANNEX B: Exposures from radiation sources.

# Building a COVID-19 Vulnerability Index Map for Hanoi City using Spatial Analysis Models

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**Abstract:** While Vietnam and the rest of the world are pushing back against the COVID-19 pandemic, new SARS-CoV-2 variants still pose a risk of resurgence. To help Vietnam safely coexist with the virus, it's crucial to have supportive information for epidemic prevention, especially disease risk maps based on spatial data. This paper outlines a method for creating a COVID-19 sensitivity map of Hanoi using QGIS. This map identifies areas at high risk for rapid infection from initial community cases and potential outbreaks, providing valuable information for the government to prioritize vaccine distribution and implement effective prevention measures.

*Keywords*: COVID-19, CVI map, Hanoi.

## 1. Introduction

The world is grappling with an unprecedented health crisis: the COVID-19 pandemic. This new coronavirus has become a global threat, affecting nearly every aspect of human life. With no specific medication yet available for prevention or treatment, controlling COVID-19's spread relies heavily on community efforts and non-pharmaceutical interventions (NPIs). These include measures like social distancing, protecting vulnerable groups, limiting public gatherings, and implementing lockdowns, all aimed at minimizing person-to-person transmission (Nande, Adlam et al. 2021).

Fortunately, studies from various countries, including the US, India, UK, Brazil, Bangladesh, the European Union, and Palestine, have demonstrated the effectiveness of disease risk maps in improving epidemic prevention. These maps have played a crucial role in saving lives and mitigating the pandemic's economic and social impact (Amram, Amiri et al. 2020; Acharya and Porwal

2020; Nicodemo, Barzin et al. 2020; Daras, Alexiou et al. 2021; Santos, Siqueira et al. 2020; Rahman, Islam et al. 2021; Fu, Wang et al. 2021; Shadeed and Alawna 2021). Consequently, many such maps, like the COVID Vulnerability Index Map and Pandemic Vulnerability Index Map, have been developed since the pandemic began. Their purpose is to pinpoint high-risk areas for outbreaks and then propose tailored, effective responses based on local population, living conditions, infrastructure, and healthcare resources, thereby minimizing casualties and sustaining economic activity (Acharya and Porwal 2020).

Many nations have reported creating COVID-19 risk maps using diverse methods. Geographic Information Systems (GIS), for instance, are invaluable tools for understanding disease patterns (Raju K, Lavanya R et al. 2020). GIS provides an excellent framework for integrating disease data with population distribution, social and healthcare facilities, and the natural environment. It also helps analyze data and identify trends. Approaches like multi-criteria analysis with GIS have been used for hazard evaluation in urban lockdowns (Sangiorgio and Parisi 2020), to create vulnerability maps in Palestine (Shadeed and Alawna 2021), and to generate COVID-19 vulnerability maps in West Bengal, India, aiding government efforts in disease management (Malakar 2022). This method has also been applied to model COVID-19 vulnerability in China (Gao, Jiang et al. 2022), assess risk (Wyszyński, Grudziński et al. 2022), identify social vulnerability indicators in Iran (Moslehi, Dehdashti et al. 2023), and map susceptibility (Sarkar 2020).

Beyond GIS-based multi-criteria analysis, satellite imagery, remote sensing, and geospatial data are crucial for identifying factors linked to COVID-19's global spread and mortality (Dahu, Alaboud et al. 2023). Experts believe remote sensing will significantly improve pandemic monitoring and management in the future (Mehmood, Bao et al. 2022). This technology has been widely used during the pandemic; for example, in India, remote sensing, GIS, and local knowledge helped manage COVID-19 by spatially defining hazard zones and permitted activities (Kanga, Sudhanshu et al. 2022). Satellite images also analyzed SARS-CoV-2 infection in Ecuador (Toulkeridis, Seqqat et al. 2022), and a combination of Bayesian networks and GIS modeled vulnerable regions in Bangkok, Thailand, leading to vulnerability management strategies.

Crucially, spatial data serves as vital input for these disease risk models (Amram, Amiri et al. 2020). By analyzing the locations of COVID-19 cases, we can identify correlations between spatial information like population density, per capita income, and living conditions, and the risk of outbreaks (Acharya and Porwal 2020). This data can be sourced from open platforms or indirectly derived from existing spatial data, such as land cover distribution or population figures (Franch-Pardo, Napoletano et al. 2020).

In Vietnam, similar studies have focused on diseases like malaria (Bui and Pham 2016), shigellosis-induced diarrhea (Kim, Ali et al. 2008), and dengue fever in Hanoi (Thanh Toan, Hu et al. 2013). These studies highlight how geographic and spatial information can enhance disease prevention, protect lives, and ensure health safety. GIS technology has also proven effective in zoning COVID-19 risk for decentralized impact levels (Canh, Son et al. 2022). While local geographical regression models have been applied to forecast and zone epidemic areas in Hanoi (Sơn, Nga et al. 2022), the rapid and novel nature of COVID-19 means there's limited prior experience or extensive spatial data studies for forecasting and identifying its risks in Vietnam. This current study aims to address this gap by using spatial data and GIS to develop spatial analysis models for creating COVID-19 sensitivity maps for Hanoi city.

## 2. Study area

Hanoi, the capital of the Socialist Republic of Vietnam, is a crucial center for the nation's politics, economy, culture, science, and technology (Uy and Nakagoshi 2008). Geographically positioned in the Northern Red River Delta (20°53′–21°23′ N latitude, 105°44′–106°02′ E longitude), it is Vietnam's most populated region. Its vast area of over 21,000 km2 accommodates nearly 22 million people, with over 8 million living in its urban areas (General Statistics Office 2020). The terrain around Hanoi varies, from southeastern coastal plains to mountains and hills in the north and west, which are home to significant national parks such as Ba Vi and Tam Dao (Van den Berg, Van Wijk et al. 2003).

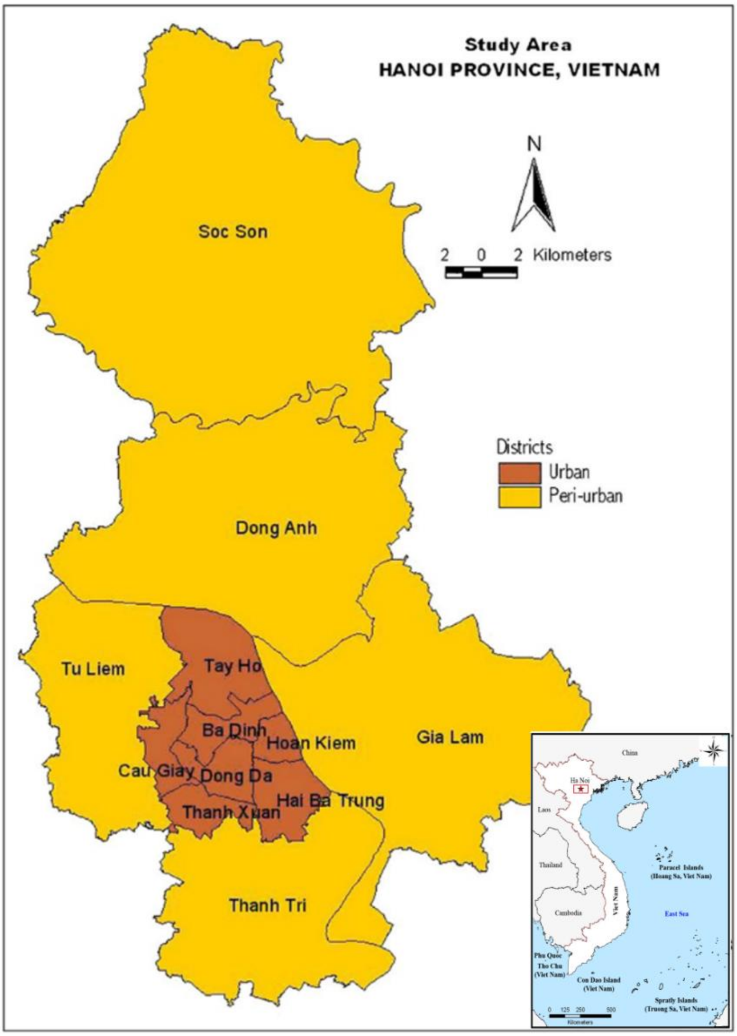


Figure 1. The study area (Thapa and Murayama 2008)

## 3. Methodology and data

### *3.1 Used data*

For this research, we collected COVID-19 infection data for Hanoi from July 5, 2021 to September 22, 2021 was collected at the Ha Noi Center for Disease Control (CDC Hanoi - 70 Nguyen Chi Thanh, Dong Da, Hanoi); At the same time, some necessary spatial data for establishing disease risk index maps are also obtained such as: land cover data, population data and population distribution, and local market data, commercial centers, apartments, data on industrial parks, etc. in Hanoi city. Table 1 shows the data and sources used in the study

Table 1. Sources and data used in the study

| Data | Discription | Source |
|---|---|---|
| Population density | | (http://www.worldpop.org.uk/) |
| Land cover | 2019 - 2021 | https://www.eorc.jaxa.jp/ |
| Land cover | 10m resolution | Sentinel – 2, Global data 2020 |
| Location of local markets in Hanoi City | 2019 - 2021 | Google Earth |
| Location of local markets in Hanoi City | July 5, 2021 to September 22, 2021 | Ha Noi Center for Disease Control |

We used the locations of over 3,500 F0 cases in Hanoi City (due to the lack of coordinate information, the team had to manually perform geocoding) were used for comparison with the model's results.

### *3.2 Methodology*

Our approach to identifying sensitive areas for COVID-19 is based on the concentration of F0 cases within a specific geographic area (once their locations are mapped). We determined an area's sensitivity by calculating the ratio of the area with F0 cases (which could be a ward, commune, district, neighborhood, or residential group) to the total study area. A higher ratio indicates greater sensitivity.

Furthermore, to facilitate centralized community screening, we calculated a sensitivity index of each size cell 100x100m (equivalent to 01 hectare) includes the total population within a radius of 500 meters and distance from each cell to sensitive geographical objects that easily become centers of epidemic spread such as markets, supermarkets, apartments, industrial areas, commercial centers, etc.

Calculate sensitive indicators for subjects such as: population density, markets, apartment, industrial areas, shopping centrer, and supermartket on each cell based on the number of people within 500 m in the area with F0 cases, distance from the areas where there are sensitive geographical objects mentioned above to the locations of the F0 cases. From there, the composite sensitivity index is determined based on the following formula (Sơn, Nga et al. 2022):

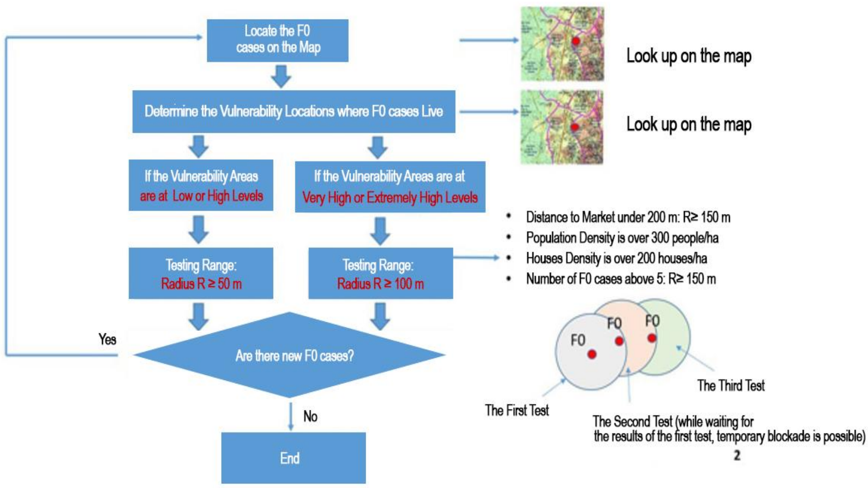


Figure 2. Focused community screening testing

$$Sensitive\_Index_i = W_{Po}*Po\_Index_i + W_{Ma}*Ma\_Index_i + W_{Ap}*Ap\_Index_i + W_{Su}*Su\_Index_i + W_{In}*In\_Index_i + W_{Sh}*Sh\_Index_i \quad (1)$$

In which: $W_{Po}$ $W_{Ma}$ $W_{Ap}$ $W_{Su}$ are the weights of sensitive factors such as population density, market, apartment building, supermarket, industrial area, shopping centre respectively.

Because the collected data is not large enough, in this study, the weight values of the above mentioned objects are considered the same and equal to 1

The relative composite sensitivity index value is calculated based on the following formula (Sơn, Nga et al. 2022):

$$Relative\_Sensitive\_Index_i = 100 * \frac{Sensitive\_Indexi}{Max\_of\_Sensitive\_Index} \quad (2)$$

The research team used open source software Quantum GIS (QGIS) to build spatial analysis models for establishing a map of the risk of COVID-19 infection. According to (Maitieg, Aljamel et al.), in addition to supporting all of the features of a GIS, QGIS is an open-source, cross-platform GIS that operates as a desktop program. Spatial data can be conveniently examined, modified, and analyzed by utilizing QGIS. In order to develop the COVID-19 susceptibility map, it is necessary to prepare base data including population density, land cover, location of local markets in Hanoi City. Then, ading the base layer map and the vector data. The result maps are generated by using QGIS software.

## 4. Results and discussion

The COVID-19 vulnerability map of Hanoi city was established based on data collected in the period from April 27, 2021 to September 7, 2021 (Figure 3). This map is used to determine the risk and speed of epidemic spread in Hanoi when the epidemic is uncontrollable. This map shows specific information about the testing locations, centralized quarantine places, the patient's home area, the locations the patients come within 14 days and after 14 days, and the position of the hospitals and medical centers, location of blockade and medical quarantine area. In addition, the areas with five risk levels display on the map including low, moderate, high, very high, and extremely high.

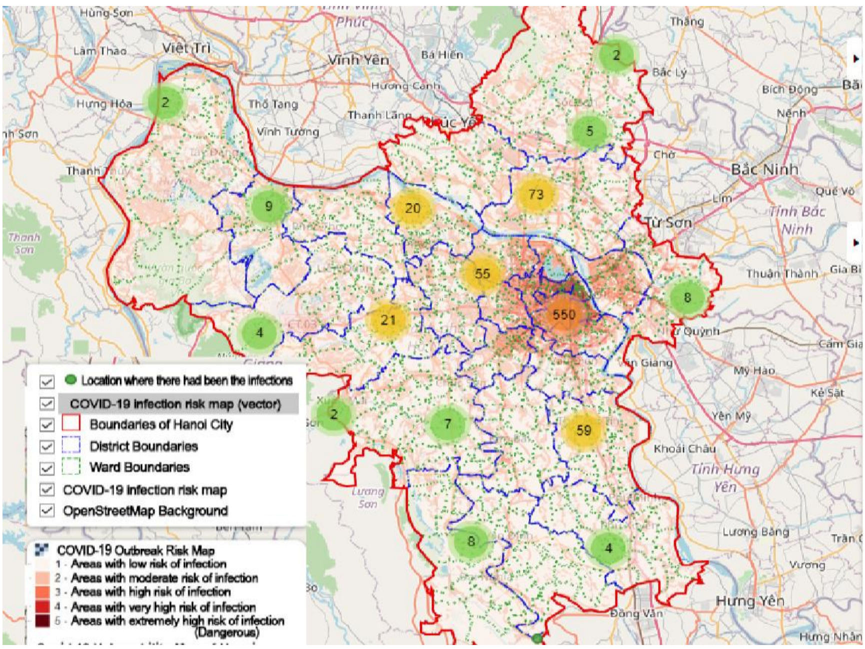


Figure 3. COVID-19 Vulnerability Map of Hanoi city

In addition, data on the number of positive cases, COVID-19 infected cases per day, F1, F2 cases, deaths, recovered cases, test samples and people waiting to be tested in areas of Hanoi city is also extracted from the map (Figure 4).

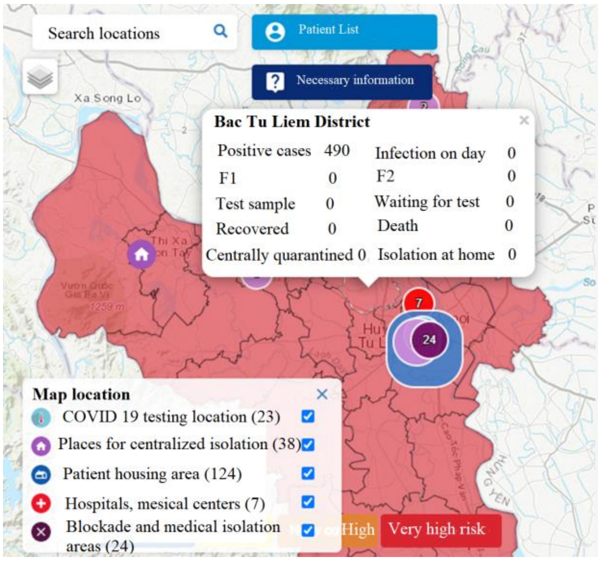


Figure 4. Statistics on the COVID-19 epidemic in Bac Tu Liem district, Hanoi city

In addition, based on indicators of population density, distance to densely populated locations such as markets, shopping centers, industrial parks, supermarkets, shopping centre, etc., the risk map of COVID 19 infection in Hanoi city was also established (Figure 5). On this map, the risk level is divided into 4 levels: normal, risk, high risk, and very high risk.

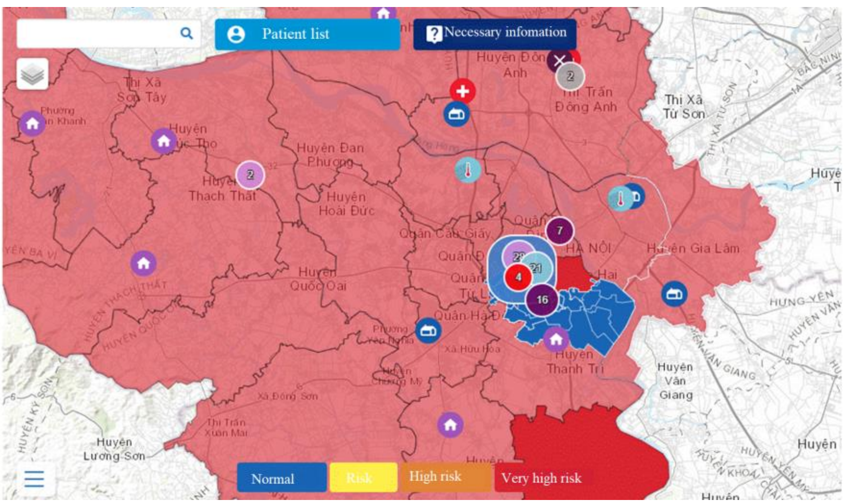


Figure 5. The risk map of COVID 19 infection in Hanoi city

Notably, information related to the epidemic in any location can also be accessed. Figure 6 is an example of data search in Thanh Xuan district:

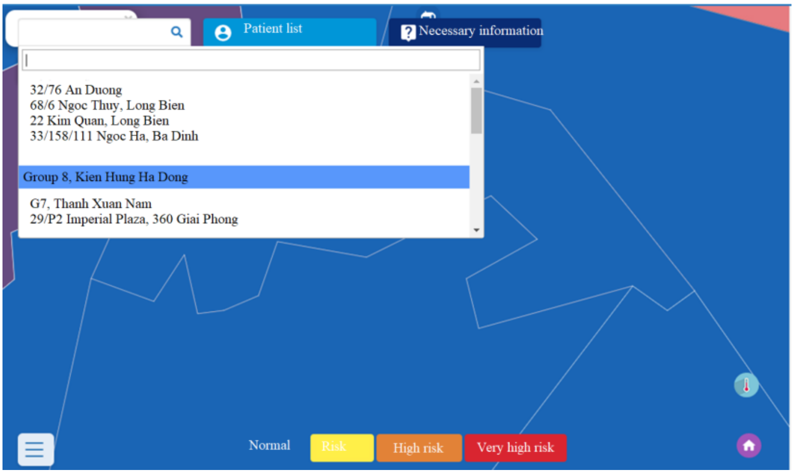


Figure 6. Search any area in Hanoi city

In addition to the number of F0, F1, F2 cases, etc., a specific list of each F0 case in the search area is also displayed on the map (Figure 7).

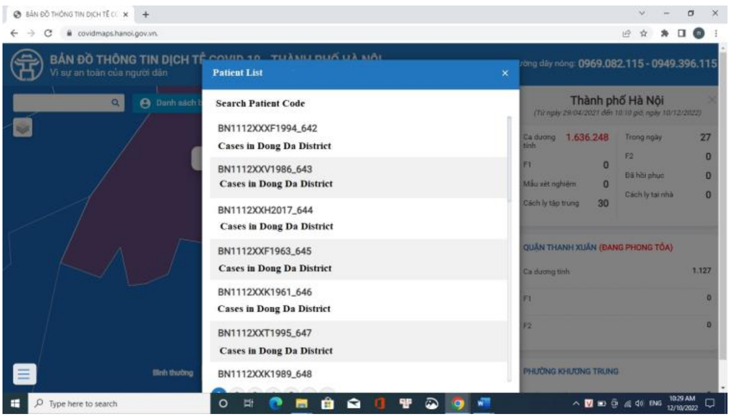


Figure 7. Displaying the list of F0 patients in the search area

The application method for research is based on geographical factors such as population, traffic, apartments, etc., so the ability to detect F0 is faster and more focused. In addition, the method used does not depend on the administrative boundaries between two communes or neighborhoods, thus the ability to detect F0 is a larger area in one test. At the same time, based on the risk index map and infection risk map, the determination of testing areas is flexible, narrowed or expanded depending on the actual detection of F0 cases and the residence characteristics of F0 cases. Based on terrain characteristics, it is possible to reduce the radius of the testing area, thereby reducing the objects of the testing area (For example: separated by canals, large roads, etc.), which means that the cost of testing is reduced. However, this method requires map data with the necessary information to determine the scope of the testing area. Furthermore, in order to the obtained results to be highly reliable, the coordination of testing between neighborhoods and neighborhoods and wards and wards in adjacent areas must be tight and synchronous. Most importantly, there is a risk of missing F0 cases when compared to testing the entire neighborhood or ward.

## 5. Conclusion

This research introduces a method for creating a COVID-19 sensitivity map of Hanoi using QGIS technology. These maps are designed to pinpoint high-risk areas for epidemic development, allowing for the implementation of tailored and effective adaptation strategies. These strategies will consider factors like population conditions, living situations, infrastructure, and healthcare resources. The ultimate goal is to minimize human losses while simultaneously maximizing economic stability. Furthermore, this research develops models that identify disease risk indicators from spatial data and uses spatial analysis models to generate crucial information for epidemiological modeling. This includes details on population density, living conditions, and demographic data (like age). This work serves as a vital preparation for responding to future outbreaks of respiratory and other infectious diseases.

## Conflicts of Interest

The authors declare no conflict of interest.

## References

1. Acharya, R. and A. Porwal (2020). "A vulnerability index for the management of and response to the COVID-19 epidemic in India: an ecological study." The Lancet Global Health **8**(9): e1142-e1151.

2. Amram, O., S. Amiri, R. B. Lutz, B. Rajan and P. Monsivais

(2020). "Development of a vulnerability index for diagnosis with the novel coronavirus, COVID-19, in Washington State, USA." Health & place **64**: 102377.

3. Bui, T. Q. and H. M. Pham (2016). "Web-based GIS for spatial pattern detection: application to malaria incidence in Vietnam." SpringerPlus **5**(1): 1-14.
4. Canh, K. M., B. H. Son and L. T. Chon (2022). "Gis app proposed solutions to construction risk of Covid–19 in
5. Thu Duc City." Journal of Hydro -Meteorology(4): 382-388.
6. Dahu, B. M., K. Alaboud, A. A. Nowbuth, H. M. Puckett, G. J. Scott and L. R. Sheets (2023). "The Role of Remote Sensing and Geospatial Analysis for Understanding COVID-19 Population Severity: A Systematic Review." International Journal of Environmental Research and Public Health **20**(5): 4298.
7. Daras, K., A. Alexiou, T. C. Rose, I. Buchan, D. Taylor-Robinson and B. Barr (2021). "How does vulnerability to COVID-19 vary between communities in England? Developing a small area vulnerability index (SAVI)." J Epidemiol Community Health **75**(8): 729-734.
8. Franch-Pardo, I., B. M. Napoletano, F. Rosete-Verges and L. Billa (2020). "Spatial analysis and GIS in the study of COVID-19. A review." Science of the total environment **739**: 140033.
9. Fu, S., B. Wang, J. Zhou, X. Xu, J. Liu, Y. Ma, L. Li, X. He, S. Li and J. Niu (2021). "Meteorological factors, governmental responses and COVID-19: evidence from four European countries." Environmental research **194**: 110596.
10. Gao, Z., Y. Jiang, J. He, J. Wu, J. Xu and G. Christakos (2022). "An AHP-based regional COVID-19 vulnerability model and its application in China." Modeling earth systems and environment: 1-14.
11. General Statistics Office, G. (2020). "Statistical Yearbook of Vietnam 2019." Statistical Publishing House: Hanoi,
12. Vietnam.
13. Kanga, S., Sudhanshu, G. Meraj, M. Farooq, M. Nathawat and S.

K. Singh (2022). "Reporting the management of COVID-19 threat in India using remote sensing and GIS based approach." Geocarto International **37**(5): 1337-1344.
14. Kim, D. R., M. Ali, V. D. Thiem, J.-K. Park, L. von Seidlein and J. Clemens (2008). "Geographic analysis of shigellosis in Vietnam." Health & place **14**(4): 755-767.
15. Maitieg, A., A. Aljamel and W. Eltarjaman "A Framework for Deploying GIS Applications to Monitor the Spatial Distribution of Epidemics. COVID-19 Epidemic in Libya Case Study."
16. Malakar, S. (2022). "Geospatial modelling of COVID-19 vulnerability using an integrated fuzzy MCDM approach: a case study of West Bengal, India." Modeling Earth Systems and Environment **8**(3): 3103-3116.
17. Mehmood, K., Y. Bao, S. Mushtaq, M. A. Khan, N. Siddique, M. Bilal, Z. Heng, L. Huan, M. Tariq and S. Ahmad (2022). "Perspectives from remote sensing to investigate the COVID-19 pandemic: A future-oriented approach." Frontiers in Public Health **10**: 938811.
18. Moslehi, S., A. Dehdashti, B. Pourmohammdi and F. Fatemi (2023). "Main social vulnerability indicators in the COVID-19 pandemic in Iran." Frontiers in Public Health **11**: 1080137.
19. Nande, A., B. Adlam, J. Sheen, M. Z. Levy and A. L. Hill (2021). "Dynamics of COVID-19 under social distancing measures are driven by transmission network structure." PLoS computational biology **17**(2): e1008684.
20. Nicodemo, C., S. Barzin, D. Lasserson, F. Moscone, S. Redding and M. Shaikh (2020). "Measuring geographical disparities in England at the time of COVID-19: results using a composite indicator of population vulnerability." BMJ open **10**(9): e039749.
21. Rahman, M. R., A. H. Islam and M. N. Islam (2021). "Geospatial modelling on the spread and dynamics of 154 day outbreak of the novel coronavirus (COVID-19) pandemic in Bangladesh towards vulnerability zoning and management approaches." Modeling earth systems and environment **7**: 2059-2087.

22. Raju K, Lavanya R, Manikandan S and Srilekha K (2020). "Application of GIS in COVID - 19 Monitoring

23. and Surveillance." International Journal for Research in Applied Science & Engineering Technology (IJRASET) **8**(V).
24. Sangiorgio, V. and F. Parisi (2020). "A multicriteria approach for risk assessment of Covid-19 in urban district lockdown." Safety Science **130**: 104862.
25. Santos, J. P. C. d., A. S. P. Siqueira, H. L. F. Praça and H. G. Albuquerque (2020). "Vulnerability to severe forms of COVID-19: an intra-municipal analysis in the city of Rio de Janeiro, Brazil." Cadernos de Saúde Pública **36**.
26. Sarkar, S. K. (2020). "COVID-19 susceptibility mapping using multicriteria evaluation." Disaster medicine and public health preparedness **14**(4): 521-537.
27. Shadeed, S. and S. Alawna (2021). "GIS-based COVID-19 vulnerability mapping in the West Bank, Palestine." International Journal of Disaster Risk Reduction **64**: 102483.
28. Sơn, B. H., D. T. T. Nga and Đ. T. B. Lê Trung Chơn (2022). "Dự báo khu vực lan truyền nhạy cảm Covid–19 dựa vào phương pháp hồi quy."
29. Thanh Toan, D. T., W. Hu, P. Quang Thai, L. Ngoc Hoat, P. Wright and P. Martens (2013). "Hot spot detection and spatio-temporal dispersion of dengue fever in Hanoi, Vietnam." Global health action **6**(1): 18632.
30. Thapa, R. B. and Y. Murayama (2008). "Land evaluation for peri-urban agriculture using analytical hierarchical process and geographic information system techniques: A case study of Hanoi." Land use policy **25**(2): 225-239.
31. Toulkeridis, T., R. Seqqat, M. T. Arias, R. Salazar-Martinez, E. Ortiz-Prado, S. Chunga, K. Vizuete, M. Heredia-R and A. Debut (2022). "Volcanic Ash as a precursor for SARS-CoV-2 infection among susceptible populations in Ecuador: A satellite Imaging and excess mortality-based analysis." Disaster Medicine and Public Health Preparedness **16**(6): 2499-2511.

32. Uy, P. D. and N. Nakagoshi (2008). "Application of land suitability analysis and landscape ecology to urban greenspace planning in Hanoi, Vietnam." Urban Forestry & Urban Greening **7**(1): 25-40.
33. Van den Berg, L. M., M. S. Van Wijk and P. Van Hoi (2003). "The transformation of agriculture and rural life downstream of Hanoi." Environment and Urbanization **15**(1): 35-52.
34. Wyszyński, M., M. Grudziński, K. Pokonieczny and M. Kaszubowski (2022). "The assessment of covid-19 vulnerability risk for crisis management." Applied Sciences **12**(8): 4090.

Figue 1. Geological and mineral map of the survey area [

# KEYNOTE SPEAKERS

# Artificial Intelligence and the Future of Work

John Howard

MD, MPH, JD, LLM, MBA

*Director of NIOSH (NIOSH)/CDC*

*The National Institute for Occupational Safety and Health*

**Abstract:**

"New employment arrangements, the pace of technological advances in the workplace, and changing workforce demographics have led international organizations, national governments, and private sector consultancies to offer views about how the future of work will be affected by these trends.

Emerging technologies - sensors, robotics, cyber-physical systems, cloud and quantum computing, advanced manufacturing, and Artificial intelligence (AI) - have captured most of the attention in future-of-work reports. While the picture of what the far future of work will look like is not entirely clear, the role of AI in the workplace of the near future is becoming more integral in a firm's business strategy."

**Bio Sketch for conference:**

John Howard serves as the Director of the National Institute for Occupational Safety and Health and the Administrator of the World Trade Center Health Program in the U.S. Department of Health and Human Services in Washington, D.C. He first served as Director of NIOSH from 2002 through

2008, and again from 2009 to 2015. He was re-appointed to a third six-year term in 2015 and a fourth six-year term in 2021. Prior to his appointment as Director of NIOSH, Dr. Howard served as Chief of the Division of Occupational Safety and Health in the California Department of Industrial Relations, Labor and Workforce Development Agency, from 1991 through 2002.

Dr. Howard received his Doctor of Medicine from Loyola University of Chicago, his Master of Public Health from the Harvard School of Public Health, his Doctor of Law from the University of California at Los Angeles, and his Master of Law in Administrative Law and his Master of Business Administration in Healthcare Management from the George Washington University in Washington, D.C.

Dr. Howard is board-certified in internal medicine and occupational medicine. He is admitted to the practice of medicine and law in the State of California and in the District of Columbia, and he is a member U.S. Supreme Court bar. He has written numerous articles on occupational health law and policy and serves as a professorial lecturer in environmental and occupational health in the Milken Institute School of Public Health at The George Washington University in Washington, D.C.

# Emerging Occupational Diseases and Compensable Illnesses: Tin and COVID-19

Doan Ngoc Hai

*Chairman, Board of Trustees*

*Hanoi University of Public Health*

**Abstract:**

Vietnam's rapid industrialization has led to an increase in occupational diseases, particularly in high-risk sectors such as mining, construction, and healthcare. This presentation examines emerging occupational hazards, focusing on tin exposure and COVID-19, two significant risks to worker health. The tin poisoning incident at Quang Phong Co., Ltd. serves as a critical case study, demonstrating the severe consequences of inadequate safety measures, including fatalities and neurological damage. This incident underscores the need for regulatory authorities to expand the list of occupational diseases and enforce stricter safety standards, especially for emerging risks like tin poisoning.

The recognition of COVID-19 as an occupational disease ensures that workers exposed to the virus, particularly in healthcare and essential services, are eligible for social insurance benefits, covering both immediate and long-term health effects such as long COVID. This inclusion reflects the importance of adaptive policies to protect workers in evolving industrial environments.

The active participation of research experts is encouraged to identify and study new occupational hazards. Continuous research-driven insights will aid in the early detection of occupational diseases and the formulation of relevant safety policies. Furthermore, regulatory bodies must regularly update the list of recognized occupational diseases to ensure comprehensive protection and compensation for affected workers.

International collaboration remains essential, and this presentation emphasizes the need for partnerships between universities, research institutes,

and global organizations to foster capacity building through workshops, training programs, and policy development. These collaborations will enhance the capabilities of policymakers, safety officers, and occupational health professionals in managing occupational risks.

In conclusion, addressing the rising number of occupational diseases in Vietnam requires a multifaceted approach. By integrating regulatory enforcement, scientific research, and international cooperation, the country can ensure better protection of its workforce, safeguarding workers' rights and health in an evolving industrial landscape.

**Bio Sketch for conference:**

Dr. Doan Ngoc Hai is the current appointed Chairman of the board of trustees of Hanoi University of Public Health. He started working at the National Institute of Occupational and Environmental Health, an agency within the Ministry of Health, since 2007 as Head of General Division. In 2013, he was promoted to Vice Director and in June of 2014, he was appointed as General Director. Dr. Doan earned his M.D. degree in General practice from Hanoi Medical University in 1995, a PhD in public health, and a MBA degree.

# Global Collaboration for Occupational Health and Safety

Marianne Levitsky

*Senior Industrial Hygiene Associate*

*Co-founder - Workplace Health Without Borders*

**Abstract:**

As members of a relatively small profession, occupational health and safety (OHS) specialists share a cohesive community and culture that enable us to forge international bonds based on our shared knowledge and passion for prevention. These traits have helped us build successful global partnerships to promote OHS. This talk will highlight opportunities for non-profit organizations and volunteers to build capacity, knowledge and skills in OHS in underserved areas. Workplace Health Without Borders is an all-volunteer non-profit organization that has engaged highly qualified professionals, including occupational hygienists and occupational medicine specialists, as volunteer trainers to teach OHS courses. Members have also been involved in projects to assess and control work-related hazards. Examples will be shared that point to the need for capacity-building and the extensive volunteer resources available in the OHS professions. The presentation will also highlight the need for collaboration to raise the profile of OHS on the global agenda beyond the OHS community.

## Bio Sketch for conference:

Marianne Levitsky was founding President of Workplace Health Without Borders, a non-profit organization that engages volunteers in promoting occupational health for workers everywhere. A senior associate with ECOH, an Ontario consulting firm, she was previously Director, Prevention Best Practices in the Ontario Workplace Safety and Insurance Board (WSIB), an occupational hygienist with the Ontario Ministry of Labour, and a co-founder of the Toronto Workers' Health and Safety Legal Clinic. She is adjunct faculty at the University of Toronto, was a member of the Toronto Board of Health, and has been appointed to the Ontario Workplace Safety and Insurance Board Scientific Advisory Table. Marianne has received the Hugh Nelson award for excellence in occupational hygiene from the Occupational Hygiene Association of Ontario and the Yant Award from AIHA. She has served as chair of the AIHA International Affairs Committee, delivered the 2020 Jeffrey Lee Lecture for ACGIH and is an AIHA Fellow and Distinguished Lecturer.

# The Business Value of Managing for Workplace Safety

David Michaels

*Professor of Environmental & Occupational Health*

*Milken Institute School of Public Health*

*George Washington University, Washington, DC USA*

*https://www.drdavidmichaels.com/*

**Abstract:**

There is compelling evidence that implementing robust collaborative workplace safety management practices can significantly improve productivity and business value, while preventing injuries, illnesses, and deaths among a firm's workforce. Businesses that hope to achieve operational excellence are greatly aided by involving workers in risk identification and mitigation. This generally increases productivity, and also fosters a culture of trust, leading to higher motivation and worker loyalty. Beyond these financial gains, prioritizing safety also demonstrates corporate responsibility, enhancing the company's brand reputation. This will become increasingly important as the worker safety practices of firms involved in global supply chains become the focus of European Due Diligence Laws.

## Bio Sketch for conference:

David Michaels, PhD, MPH, is an epidemiologist and professor at George Washington University School of Public Health. He served as the longestserving Assistant Secretary of Labor for OSHA from 2009 to 2017, where he strengthened exposure standards and launched several initiatives, including the Temporary Workers Initiative and sustainability activities.

Earlier, he was the Department of Energy's Assistant Secretary for Environment, Safety, and Health from 1998 to 2001, where he led the initiative to compensate workers in the nuclear weapons complex. Michaels has also served on the US National Toxicology Program's Executive Committee and contributed to COVID-19 worker protection efforts.

He is a leader in advocating for scientific integrity and has authored books on the subject. Michaels has received numerous awards for his work, including the AAAS Scientific Freedom and Responsibility Award and the APHA's David P. Rall Award for Advocacy in Public Health, the John P. McGovern Science and Society Award given by Sigma Xi, the Scientific Research Society, and the American Conference of Governmental Industrial Hygienists' William D. Wagner Award and William Steiger Memorial Award.

# Building a Safer Tomorrow: Designing a Comprehensive Workplace Health and Safety Strategy

Nicole Greeson

*President of AIHA*

*American Industrial Hygiene Association*

*AIHA to Vietnam Delegation Leader*

**Abstract:**

It is important to design and implement a comprehensive strategy to address health and safety hazards in the workplace. Conducting assessments to identify and stratify risks and then prioritizing and implementing controls to address those risks are keys to prevent injuries and illnesses. Examples and resources will be provided.

## Bio Sketch for conference:

Ms. Nicole Greeson, MS, CIH is the current President of AIHA. She is Associate Director of the Occupational and Environmental Safety Office as well as Director of the Occupational Hygiene and Safety Division at Duke University and Health System in Durham, NC, USA. She has over 20 years of experience practicing comprehensive industrial hygiene and general safety.

Nicole received her Bachelor of Science in Public Health (BSPH) degree in Environmental Sciences from the University of North Carolina at Chapel

Hill. She has a Master's degree in Environmental Sciences with an Industrial Hygiene focus from the University of Texas Health Science Center at Houston.

Her professional volunteer experience includes serving as a past Treasurer of AIHA and previous service on the Academy of Industrial Hygiene (AIH) Council and the American Board of Industrial Hygiene (ABIH), now the Board for Global EHS Credentialing (BGC), which she chaired from Oct. 2014-Oct. 2015.

# LIST OF ABSTRACTS

# Asbestos in Talc

Dorothy Cook

*MSc, LFOH, Occupational Hygiene Consultant, WHWB-UK Treasurer and Secretary*

**Corresponding author, Email address: dorothyjcook12@hotmail.com*

**Abstract:**

Talc and asbestos are both naturally occurring minerals that can be found in the same area of the earth. During mining and processing, talc can become contaminated with asbestos.

Talc has been used in cosmetics for many years, but it wasn't until recently that scientists began to understand the link between talc and cancer, leading consumers to wonder how talc products can cause cancer.

Since 1976, the FDA and the cosmetic industry have insisted that talcum powder products are asbestos-free. Evidence from studies and reports shows talc products do sometimes contain asbestos.

Paradoxically, talc used in the pharmaceutical industry is completely asbestos free, due to manufacturing standards that meet the United States Pharmacopeia-National Formulary (USP-NF), British Pharmacopeia (BP) and European Pharmacopoeia (EP) monographs.

The health implications for the different grades of talc are discussed in this presentation.

# Silicosis prevelence and Associated Factors Among High Risk Population Group in Viet Nam in 2018 - 2019

Pham Thi Quan

*Hanoi Medical Univerity*

**Corresponding author, Email address: phamthiquan@hmu.edu.vn*

**Abstract:**

Despite silicosis being one of the oldest occupational diseases, it continues to be leading occupational disease worldwide and in Viet Nam. The study aims to determine the prevalence and associated factors for the development of silicosis among workers directly exposed to silica dust. In a cross-sectional survey of 4002 worker in five provinces, in which having many enterprises using silica in their products. Of which, two provinces (Hai Duong and Thai Nguyen) were representative for the North region, a province (Binh Dinh an Phu Yen) were from the central region, and Dong Nai provinces was from the South of Viet Nam. Inclusion criteria of the study population were worker (1) exposed directly to silica while working; (2) agreed to be face to face interviewed to provide information related to silica at the workplace; (3) agreed to have pulmonary occupational disease examination with chest X-ray film; (4) accepted by signing a witten consent form. After discussing with Center Diseases Control in 5 selected provinces, a total of 4002 workers satisfied all criteria of the study and attended the study between Octorber 2018 and May 2019. Social-demographic and occupational health charateristics were collected through a face-to-face interview and a chest X-ray performed by medical staff and preumoconionsis radiologists. Logistic multivari-ate regression was applied to analyze risk factors associated with silicosis. In this study, the overall prevalence of silicosis was 12,27%. This prevalence is lower than in the other studies on the incidence of silicosis in both other countries and Viet Nam. The prevalence was higher in male (13,2%) than female (7,9%) with p< 0,001; In total, the mean of silica exposure time was 10,6 years

(SD=7,6). 53,7% of participants worked in building material, 72,5% of participants had shift working .Prevalence also increased with older age group, and was higher in exploiting and processing stones and granite quarrying. Workers exposure with silica dust more than 15 years were more likely positive with silicosis. Male, older age group, type of work such as exploiting and processing stones and granite quarrying, worker who unknown silicosis can be preventive, and the long distance to health facilities were significantly associated with silicosis. Our findings indicate the importance of reviewing the silicosis diagnosis, particularly time exposure. Further intervention to prevent silicosis must be prioritized for male, older worker, tailored by type of work, and improving of knowledge and practices against silicosis of the workers.

# Recent exposure data from Canada on respirable crystalline silica and elemental carbon exposure in underground mining

Victoria H. Arrandale[1], Ali Shakeel [1], Kevin Hedges [2*], Kimberly O'Connell [2], Melanie Gorman Ng [3]

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[2] *Occupational Health Clinics for Ontario Workers, Ontario, CANADA*

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**Corresponding author, Email address: kevinhedges.kh@gmail.com*

**Abstract:**

Introduction: Mining is a high hazard industry with significant occupational disease risks. Despite this there is limited data describing current exposure conditions. The aim of this short communication is to share recent exposure data from underground mines in Ontario, Canada.

Methods: Data from underground mines were accessed through a freedom of information request. Data were cleaned and standardized. Data contained measurements of several hazards from 2013-2018; analysis focused on personal samples for respirable crystalline silica (RCS) and elemental carbon (EC) from 2014-2018. Descriptive statistics were calculated overall and by sampling year; comparisons were made to current occupational exposure limits. Linear regression models were constructed to examine time trends.

Results: EC exposures decreased significantly, approximately 10% per year over the measurement period (2014-2018). Overall 14% of EC measurements were above the current mining exposure limit (0.12mg/m3 EC) in Ontario, Canada. Results for silica did not show a statistically significant trend but did suggest a reduction of approximately 1.8% per year. Almost one-third of the RCS measurements were above the American Conference of

Governmental Industrial Hygienists (ACGIH) recommended threshold (0.025mg/m3).

Conclusions: Current exposure data is needed to understand workers' exposure and support occupational disease prevention. Recent data from the Ontario mining industry suggests that exposure to elemental carbon decreased significantly from 2014 to 2018, but the annual reduction for silica exposure was not nearly as substantial. Mining workers continue to be exposed to levels of EC and RCS that are hazardous to health.

# Silica Dust Exposure in the Museum and Cultural Heritage Field

Cusack-McVeigh, Holly[1],*, Goldsmith David F. [2]

[1]*Department of Anthropology and Museum Studies Program, Indiana University Indianapolis, 425 University Blvd, Indianapolis, Indiana, United States.*

[2] *Milken Institute School of Public Health, Department: Environmental and Occupational Health, George Washington University, 950 New Hampshire Ave, NW Washington, United States*

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**Abstract:**

Museum and cultural heritage workers conduct research and a range of other work-related activities that unknowingly put them at risk for respirable silica dust (SiO2) exposure. It is critical to ensure all museum and heritage staff are aware of these exposure risks, understand how to identify them, and properly protect themselves from these hazards. Inhaling dust from crystalline silica-containing materials can lead to a variety of known diseases, including silicosis, auto-immune diseases, cancer, kidney disease, and other ailments. Silica dust is a common, but underestimated health hazard in museum and cultural heritage field. Archeological artifacts, geological specimens, stone sculptures, historic buildings and even art supplies can be sources of silica dust. Exposure risks take many forms including the processing of archaeological and geological specimens, the cleaning of historic grave markers and sculptures and even the use of common art supplies and techniques. Serious concerns about silica countertop exposures in museum laboratories is part of the current risk picture. When working with these materials, proper personal protective equipment (PPE) should be worn, and the workspace must be wellventilated.

While not well known to museum and cultural heritage workers and supervisors, $SiO_2$ dust exposure is a common health threat in these fields. It is critical for staff to be educated on these potential exposure risks, especially for those outside healthrelated fields. Museums and cultural heritage organizations must establish policies and practices for safely cleaning, processing, or using silica-containing materials and work to mitigate staff and visitor exposures.

*Keywords*: Silica Dust Exposure, Museum Workers, Cultural Heritage Field

# What are the Global Implications of IARC's Assessment of Silica Dust as a Known Human Carcinogen?

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**Abstract:**

Background: The International Agency for Research on Cancer (IARC) reviewed the animal and human evidence for the carcinogenicity of crystalline silica (SiO2 or quartz dust) three times in 1986, 1997, and 2012. After the 1997 assessment IARC judged respirable silica to be a type 1 or known human carcinogen. This talk will review the published global epidemiological and clinical research and policy for the past 25 years addressing silica dust.

Literature Reviewed: Our review will include workers exposed to silica dust and workers diagnosed with silicosis, with a focus on lung cancer. We will assess the cancer risk among coal miners, among silica exposed nonsmokers, African workers with silicotuberculosis, children involved with artesinal gold mining, railroad workers exposed to silica ballast, and countertop workers exposed to high levels of SiO2. We will consider other cancers such as gastric, renal, and dermal malignancies as well as the risk of autoimmune and kidney diseases.

Future Concerns: Occupational health professionals know silica dust can be controlled by wearing dual cartridge respirators, applying wet methods, and applying improved dust standards. We know younger clinicians need to be aware of past findings as well as the need for novel research. Research should focus on quicker industrial hygiene dust exposure methods, understanding the biochemical or surface chemistries to distinguish silica lung tumors from 'garden variety' cancers, expanding studies to better characterize silica links with autoimmune and chronic lung illnesses, and stomach, kidney and skin cancers. Furthermore, we need studies examining interactions between silica and smoking, countetop binders, asbestos, mercury, radiation, and diesel exhaust. Lastly, a better prevention strategy is needed in the developing world where mining, smelting, construction, and countertop work predominates.

*Keywords*: Workplace silica, cancer, IARC evaluations, health impacts, prevention methods, mining, construction, smelting, countertop workers.

# Validation of a Portable Dust Generation System for Calibration of RCS Measuring Instruments

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**Abstract:**

This research work was aimed at enhancing in-field and onsite calibration of portable Respirable Crystalline Silica (RCS) instrument. Results have shown that reproducible dust clouds of any dust can be generated including the Australian RCS standard material (A9950 Aust. No.1). Testing showed that the physical characteristics of a dust can influence the generated concentration, and measures were found to improve the dust generation process for materials that exhibited adherence to surfaces. We determined four different ways of controlling the amount of dust generated and sampled out of the dust generator, thereby improving the calibration of RCS measuring instruments. The dust generation system has the potential to improve calibration of portable analytical instruments for RCS analysis.

# Assessment of some risk factors for the health of motocycle repair and maintenance workers in Thai Nguyen City in 2024

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**Abstract:**

The motorcycle repair and maintenance sector carries a number of potential health hazards, from exposure to chemicals and dust to inappropriate working conditions. We conducted a cross-sectional descriptive study in 2024 on 195 workers in Thai Nguyen City who worked in the motorcycle maintenance and repair sector. The results showed that 97.9% of workers have been exposed to chemicals, grease, or solvents at work. According to the findings, 18.5% of employees experienced abnormal skin changes in areas exposed to oil or solvents, and 13.8% of them had to take time off work to visit a medical facility for diagnosis and treatment. Dust and exhaust fumes from repairing and operating motorcycle engines were the next element evaluated to have an impact on workers' health; 13.8% of workers suffered from respiratory conditions, with sore throats accounting for the greatest rate at 55.6%. However, when exposed to them, only 64.4% of workers wear protective gear. Consequently, steps must be taken to enhance the working environment (by adding ventilation systems, lowering pollutants, etc.) and encouraging the use of protective gear.

*Keywords*: motorcycle repair and maintenance, worker, Thai Nguyen city

# Hazardous factors in the occupational environment of cement production

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**Abstract:**

**Background:** Besides the significant contributions of the cement industry to the country's economic development, environmental pollution at cement production facilities is a matter of concern. Most stages in the cement production process generate harmful factors including dust, noise, toxic gases, etc., among which dust and noise are identified as the two main risk factors affecting the health of workers. The study conducted by Tinh Thai in 2021 revealed that the noise level at cement plant S1 mostly exceeded the permissible limit, at crushing stations S2, S3, and S4, it ranged from 68.8 dBA to 103.3 dBA.

**Methodology:** A cross-sectional descriptive study was conducted at two cement companies, Vicem Hoang Thach and Vicem Hoang Mai in 2023.

**Results:** The survey results show that the production process of cement at both labor bases utilizes the dry rotary kiln technology, consisting of three main stages: raw material preparation, clinker production, and grinding of finished cement. Environmental monitoring in the workplace for each company at 16 selected positions across 3 stages shows that: 56,25% - 76,47% of samples that exceed the permissible noise intensity limit according to QCVN 24:2016/BYT, ranging from 0.8 dBA to 20.3 dBA, mainly in the high-frequency range. Specifically, the average ambient pressure is very high at certain positions, such as the air compressor area (101,3 dBA), the Z1M03 - HT1 crusher area (101,9 dBA), and the ore selection area (105,3 dBA).

There are 13,33% - 31,25% of positions with free silica concentration in the total dust exceeding the permissible limit of 0,01 - 0,49 mg/m3. 25% - 26,67% of positions have free silica concentration in the respirable dust exceeding the permissible limit of 0,01 - 0,22 mg/m3.

The concentration of chromium in the dust samples at the measurement positions ranges from 0,0002 - 0,00182 mg/m3, all of which are lower than the allowable standard according to QCVN03/2019/BYT.

**Conclusions:** Noise, dust, and chromium are the main harmful factors in the cement production workplace environment. Workers need to be equipped with adequate protective gear and comply with occupational safety regulations to protect their health. The supervision and improvement of the workplace environment should be enhanced to minimize the adverse effects of these factors.

*Keywords:* cement worker, noise, dust, chromium

# Asbestos risk assessment and prevention

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**Abstract:**

Asbestos is a naturally occurring mineral that is considered a significant occupational risk. The goal of this presentation is to provide a risk assessment methodology and generate a discussion about the myths and realities of asbestos exposure. The presenter will discuss the exposure risks and the different types of regulated asbestos fibers. Other commonly occurring natural and manmade fibers will be discussed as well. By performing risk assessments before the existing asbestos containing materials (ACM) materials are disturbed, Occupational Health, and Safety (OHS) professionals can try to prevent occupational illness from exposure to asbestos fibers. These risk assessment methods provide practical recommendation to OHS managers on the necessary precautions to prevent exposure to asbestos fibers or, where this is not reasonably practicable, to reduce exposure to asbestos fibers.

The author will present Asbestos Risk Assessment Tools. The tool provides a broad spectrum of guidance pointed at the prevention of occupational illness from exposure to respirable asbestos fibers. It is based on the Health and Safety Authority (HAS) Guidelines. One of the asbestos risk assessment tools provides a semi-quantitative risk assessment methodology. An overall score and color coding based on the level of risk is discussed.

A case study will be presented as well. Participants will receive a free copy of the asbestos risk assessment tools.

# Training Certification and Licensing Requirements for Asbestos Abatement Work in BC Canada Buildings: New Sets of Administrative Controls

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**Abstract:**

The major hazards of asbestos are well known: lung, ovarian, and gastrointestinal cancers, mesothelioma, and asbestosis. Among the first administrative control measures was recognition by the International Agency for Research on Cancer that asbestos is a human carcinogen (1987). A further step was banning the use of asbestos in new products and the import/export of asbestos. Lagging well behind the 2005 European Union prohibitions, Canada banned asbestos in 2018. Currently, the use of asbestos is banned in all Organisation for Economic Co-operation and Development countries, except the United States and Mexico, but many low- and medium-income countries have not (Curiel- Garcıa, et al 2005).

Vietnam is an example of a country that has been slower to implement a comprehensive asbestos control framework. Although Vietnam has made strides in reducing the use of asbestos, particularly in construction materials such as the Vietnam is an example of a country that has been slower to implement a comprehensive asbestos control framework. This includes the widespread use asbestos-containing roofing materials in country-side housing construction. The country still permits certain uses of chrysotile asbestos, a type of asbestos that is considered less hazardous but is still classified as a human carcinogen. Vietnam's asbestos framework includes regulations on

asbestos exposure limits, mandatory labeling of asbestos-containing materials, and the promotion of alternative materials. Given the long latency period of asbestos-related diseases, new worker and non-worker cases can be expected for a long time in the future.

Preventing exposure through the hierarchy of controls is well known by occupational, safety, health and environmental (OEHS) professionals. In spite of these measures, the number of cases of invariably-fatal mesothelioma in Canada's western-most Province of British Columbia (BC) has risen annually from about 35 cases diagnosed in 1993 to nearly 100 cases diagnosed in 2017. The scientific literature estimates that 35,000 workers are currently exposed to asbestos in BC. As a surrogate measure for all asbestos-related disease, mesothelioma rates have plateaued, but new cases will continue to be diagnosed given the long latency period (CAREX Canada).

New prevention initiatives are required to lower the burden of mortality and morbidity. In this context, our presentation explores recent experience of a new phase of administrative controls to prevent exposure to asbestos during building remediation, renovation, and demolition. These administrative controls complement the exacting requirements of safe work procedures already contained in the BC OHS Regulation.

Starting January 1, 2024, workers doing asbestos abatement work in buildings in BC are required to be trained and certified through approved training providers.

Employers engaged in building asbestos abatement are also required to be licensed. The requirements apply to employers and workers transportation of asbestos to approved landfills. These contractors are typically small employers where comprehensive compliance with asbestos remediation is historically low or non-existent. Employers with asbestos exposures not involving buildings, such as shipyards, are exempt from the new licensing and certification requirements.

Asbestos abatement work is defined as removing, repairing, transporting, or disposing of asbestos-containing material. Work typically carried out by Occupational, Safety, Health and Environmental (OEHS) professionals such as collecting/analyzing samples and assessing risk qualifies as asbestos abatement work, as does planning/supervisory activities.

Certification training divided into four levels: 1. Asbestos Foundational Awareness for transporting and/or disposing of asbestos-containing waste; 2. Asbestos Safety for workers conducting asbestos abatement work; 3. Asbestos Safety Leader which outlines supervisor training competencies for abatement projects.

The fourth component of core competencies, Asbestos Surveyors is of particular interest to OEHS professionals. It includes developing and communicating an Exposure Control Plan, conducting walkthrough surveys, determining sampling quality and quantity standards and report writing including assessment of lab reports for false positives or negative.

# A narrative review of wood dust exposure and potential health risks

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**Abstract:**

**Background:** Wood dust, generated through various wood processing activities such as grinding, sanding, cutting, milling, and debarking, remains a prevalent occupational carcinogen today.

**Objective:** To narratively review of wood dust exposure and potential health risks

**Methodology:** A narrative review was conducted utilizing various databases, including online journals, reports, and Google Scholar, using keywords such as "wood dust"; "wood dust-related legislation"; wood dust exposure"; "wood dust-related health risk"; and "Vietnam".

**Results**: Wood dust was classified as a group human carcinogen in 1995 by the International Agency for Research on Cancer (IARC) as some particle sizes (e.g., ≤4µm) derived from wood can deposit in the lungs. While hardwood (e.g.,Oak, Teak, Mahogony) dust (has been definitively classified as a human carcinogen, there is only limited evidence regarding the carcinogenicity of softwood (e.g., Pine, Spruce, Fir) dust. Exposure to hard wood dust has been associated with several health problems including sinonasal cancers, respiratory and digestive tract cancers, asthma, allergies, and lung cancer risk. A meta-analysis provides strong evidence linking hard wood dust to lung cancer, though the strength of this association is significantly affected by the geographic region of the study. Currently, wood dust exposure significantly affects workplace health, with 10% to 15% of workers being exposed. This exposure may lead to a higher mortality rate among these workers and can also influence the mortality rate in the general population. In Vietnam, wood dust is posing significant environmental risks to health and the environment. A recent study at a wood processing company in southern Vietnam showed that 11.8% of workers suffered from respiratory diseases. High proportions of workers in the carpentry village reported suffering from eye diseases (67.5%), neurological diseases (55%), ear, nose, throat diseases (36.3%), gastrointestinal diseases (18.8%), and musculoskeletal diseases (25.0%).

**Conclusions:** Given the health and social impacts of wood dust exposure, it is essential to recognize this as a prevalent occupational risk in Vietnam and implement appropriate safe work practices to protect workers in the workplace.

*Keywords*: Wood dust, hardwood dust, softwood dust, occupational exposure, respiratory-related diseases, cancer risks, Vietnam

# The current status of hearing loss among cement production workers exposed to occupational noise in 2023

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**Abstract:**

**Background:** Workers in cement production are exposed to various hazardous factors in the workplace, such as unfavorable climate conditions (high temperature, thermal radiation, etc.), noise, vibration, cement dust, chromium, unfavorable working postures, shift work, etc. Among these factors, noise is the most common and prevalent hazard encountered in most stages of cement production. Noise in some production areas such as cement factories, air compressors, fans, or crushers, in cement grinding stations fluctuates between 89 dBA and 105 dBA, exceeding the permissible exposure limit (PEL) of Vietnam (85 dBA/8-hour workday). Occupational noise-induced hearing loss is one of the prioritized health issues in the field of occupational health, not only in Vietnam but worldwide. In Vietnam occupational noise-induced hearing loss ranks second among compensated occupational diseases, with approximately 250 to 500 cases being assessed annually.

**Methodology**: The cross-sectional descriptive research method was conducted on 679 cement production workers at two cement companies, Vicem Hoang Thach and Vicem Hoang Mai, in 2023.

**Results:** The rate of hearing loss due to noise was 19.4%, highest in the cement and clinker workshops. The rate of hearing loss increased with the number of years worked, with the group with over 30 years of experience having the highest rate at 36%. The degree of hearing impairment was assessed using the Fowler Sabin chart, primarily focusing on the group with mild hearing loss, accounting for 56% - 74.6% of cases. According to the

Felmann-Lessing chart, the majority of cases (85.3% - 89.5%) experienced a loss of labor capacity ranging from 5-11%.

**Conclusions:** The rate of hearing loss due to noise exposure in cement production workers is relatively high at 19.4%, primarily affecting mild hearing loss. Workers in noisy environments are at risk of experiencing irreversible hearing loss, therefore it is crucial to use hearing protection devices properly and consistently in order to minimize and slow down the impact of noise on hearing.

*Keywords*: Cement worker, noise, hearing loss

# Fitness for Duty - Practical Approaches for Manufacturing, Mining, and Construction.

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**Abstract:**

We all know that an individual's Fitness for Duty (FFD) has a direct impact on their ability to do a job safely. However, how can we adequately assess fitness for duty? How do you avoid pitfalls and potential discrimination? With so many potential components to FFD - which may include regulatory-required medical exams, ergonomics, functional capacity evaluations, medical history & impairment, exposure management, and biological monitoring - knowing where to start can be difficult. In this presentation, we'll review practical approaches and better understand how FFD can be part of your organization's injury & illness prevention strategy.

# The Impacts of Climate Change on Construction Workers' Health and Safety

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**Abstract:**

**Background**: Climate change has massive impacts on global health including the construction workers' health and safety. It continues to pose an immediate and long term threat to human being. Workers who work outdoor, such as construction and agricultural workers are the first to be subjected to impacts of climate change often for longer periods and at greater intensities. Climate change effects can deteriorates work environment and working conditions and increase work-related injuries, diseases and deaths. More than 70% of workers, in particular outdoor workers, emergency responders, elderly and pregnant workers are at high risk of the impacts of climate change. Numerous health and safety effects such as heat stress, cancer, cardiovascular, respiratory and vector borne diseases, eye damage, agrochemical exposure, mental disorders, accidents, injuries etc. may occur because of climate change.

Climate change effects may also lead to lost productivity, business disruptions and damaged infrastructure, which has a greater impact on national economy.

**Purpose**: To highlight the importance of the climate change and it's immediate and long term effects and measures to be taken to prevent and mitigate those impacts on construction workers.

**Method**: This presentation is based on literature review of latest publications on this issue.

**Results:** Exposure to excessive heat, results in 22.85 million injuries and 18,970 deaths annually. It has been estimated that, more than 18,960 die because of work-related skin cancer due to solar UV radiation and 860,000

deaths due to air pollution, annually. In addition, more than 15,000 deaths occur as a result of work-related vector borne diseases.

**Conclusions:** Workplace in depth risk assessment, emergency preparedness, health surveillance, education and, preparation of national regulations, standards, policies and guidelines, would prevent and mitigate the impacts of climate change, to a greater extent.

*Keywords*: Climate, health, safety, injuries, diseases, construction

# Enhancing Occupational Health Outcomes: The Crucial Role of Competency and Stakeholder Collaboration

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**Abstract:**

Effective management of occupational safety and health (OSH) is a multifaceted endeavor that requires the concerted efforts of diverse stakeholders, including regulatory bodies, employers, employees, and occupational health professionals. Central to this collaborative framework is the occupational hygienist, whose role in identifying, assessing, and controlling workplace hazards is vital for ensuring a safe and healthy work environment.

This presentation will explore the critical roles and responsibilities of key OSH stakeholders, emphasizing the necessity of a cohesive approach to managing workplace health risks. This talk will delve into the specific functions of each stakeholder.

Particular focus will be given to the competencies required of occupational hygienists. Competency in this context encompasses not only technical expertise in exposure identification and control but also soft skills and ethics. The presentation will underscore how advanced training, continuous professional development, and practical experience equip occupational hygienists to effectively address complex workplace challenges and drive positive health outcomes.

The session aims to provide insights into how enhancing hygienists' competencies and promoting robust stakeholder collaboration can lead to improved safety standards and a healthier workforce.

# Enhancing Workplace Safety and Health Through Video Exposure Monitoring

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**Abstract:**

Airborne hazards pose significant risks to workers' health and safety. Traditional exposure assessment methods often lack real-time data integration and fail to capture dynamic workplace conditions. Enter video exposure monitoring (VEM), a groundbreaking approach that bridges this gap by combining video surveillance with hazard measurements, enabling precise exposure analysis. In our study, researchers at Purdue University developed a low-cost, portable, real-time sensor that measures airborne particulates containing silica while synchronizing video footage. This innovative instrument holds immense promise for industrial hygienists working in manufacturing and construction, allowing them to evaluate and control exposures effectively. One direct application of VEM is in refractory fire-brick manufacturing in Vietnam, where silica exposure is a concern. Our presentation aims to demonstrate the proof of concept that VEM can evaluate worker exposure to airborne dust containing silica, pinpointing peak exposures related to specific work processes. By analyzing work practices, general ventilation, and engineering controls, we gain valuable insights into potential solutions. What sets VEM apart is its real-time synchronization of airborne exposure levels with video data during data collection. This visualization provides a powerful tool for identifying effective interventions promptly. Moreover, these solutions can be rigorously tested for efficacy. Imagine a scenario where airborne exposures are assessed in the morning, evaluated by noon, interventions applied, and re-evaluated in the afternoon, with solutions proposed by day's end. Traditional industrial hygiene sampling protocols will further validate our results. Join me as I delve into the evolution of VEM through a series of case studies—from its early testing days at NIOSH to the present, utilizing cutting-edge video-plus-sensor technology. Our live demonstration will showcase the transformative potential of this device in enhancing workplace safety.

*Keywwords*: Video Exposure Monitoring, Real-Time Monitoring, Videography, Airborne Respiratory Hazards, Construction, Silica Exposure**.**

# Status of Occupational Environmental Monitoring at some health facilities in Vietnam in 2022-2023

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**Abstract:**

**Background**: The working environment in medical facilities directly impacts the health of patients and medical staff. Environmental factors in healthcare facilities are assessed through monitoring the work environment. What is the current status of this monitoring in hospitals? This study aims to determine the Status of Occupational Environmental Monitoring at some health facilities in Vietnam in 2022-2023 and draw conclusions.

**Methodology**: A cross-sectional study was conducted in 51 hospitals in Vietnam. We have collected, synthesised, and analysed data from available data sources on implementing labour environment monitoring in these hospitals.

**Results:** The study results show that the commonly used indicators for evaluation in hospital environments include common factors such as temperature, humidity, wind speed, noise, workplace lighting, and CO2 concentration, and hospital-specific factors such as medical radiation, Cl2 concentration, Ethanol concentration, Formaldehyde concentration (HCHO). Most hospitals have results of implementing working environment monitoring at the medium level or better, of which medium level accounts for 35%, good level accounts for 24% and excellent level accounts for 10%. However, some indicators, such as determining Cl2 concentration in the infection control department, Ethanol concentration at the workplace, and Formaldehyde concentration (HCHO), have yet to be fully considered and implemented.

**Conclusions:** The monitoring of the hospital working environment has improved in recent years. Managers must prepare a complete hospital occupational hygiene record and monitor the working environment, focusing on hospital-specific factors to ensure the medical staff's health.

*Keywords*: Working environmental monitoring, health facilities, healthcare workers

# Workplace Health Without Borders' virtual occupational health and safety training using synchronous and asynchronous methods

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**Abstract:**

**Introduction**: Training is a focus area of Workplace Health Without Borders (WHWB). There are 3.4 billion workers in the world. Nearly two-thirds of them work in unhealthy and unsafe conditions. Worldwide, there are about 8,000 certified/registered occupational hygienists and only 16 countries with professional accreditation programs. The world need is great for more trained occupational health/hygiene professionals that understand how to protect workers from workplace injury and disease.

**Materials and Methods**: This presentation will share our methods and platform for instruction. We will discuss how we pivoted during COVID to a combination of Synchronous/Asynchronous training, and how this solved several important issues for our students and Tutors and overcame other barriers to in-person training. We will present the outcomes of student evaluations and how we measure and deliver successful training.

**Results**: The impact of our Training will be presented. Our Training leads to Mentoring which leads to Networking for the students and global professionals responsible for worker well-being. We engage in-country Tutors for instruction and facilitation so that networking and mentoring is more easily attained.

**Conclusions**: Students and professionals in low to medium income countries (LMICs) lack access to occupational health/hygiene training. There is often a lack of regulations in these countries, so that prevention of exposure and protection of worker health is not addressed. However, knowledge of breaking the routes of exposure that cause disease can be used anywhere when it is understood.

*Keywords*: Occupational Health Hygiene Training asynchronous plus synchronous training, virtual l(online) training, local Tutors used, Google platform used.

# The Workplace Health Without Borders ethos and service delivery in a nutshell

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**Abstract:**

**Introduction**: Workplace Health Without Borders (WHWB) is a non-governmental organization dedicated to promoting international occupational health. This presentation will provide an overview of WHWB, and share what we have learned about the ethos and culture of the global occupational health/hygiene community.

**Materials and Methods**: WHWB's vision is a world where workers, their families and communities do not get ill because of their work. Our mission is to prevent work-related disease around the world through shared expertise, knowledge and skills. An entirely volunteer organization, WHWB leverages the expertise of its members, including occupational hygienists and health care professionals, to offer training, mentoring and technical assistance on projects to help local partners assess and control work-related hazards.

**Results:** Since its founding in 2011, WHWB has built a global network of volunteers dedicated to building international capacity for preventing work-related injury and illness. Our achievements have included numerous training programs, both in-person and virtual, that have educated occupational health/hygiene professionals who lack access to such education. Our committees devoted to specific issues, such as brick kilns, waste picking, nail salons and asbestos, have conducted projects to provide training, or assess and control hazards.

**Conclusions:** WHWB has demonstrated that occupational hygienists, physicians and other professionals have a vast reservoir of expertise that they are willing to share to build international occupational health/hygiene capacity. The expertise of volunteers is a valuable resource in improving global health, and a testament to the collaborative culture and dedication of the occupational health community.

*Keywords*:wroker health, teamwork, global vision, collaboration

# Developing Occupational Hygiene Training Opportunities in the Asian region

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**Abstract:**

**Background**: With the rapid industrialization of the Asian workforce by multinational companies seeking a plentiful workforce, at a low cost, the Asian region is rushing to catch up with international standards for workplace Occupational Health and Safety.

The need for further structured, certified training is all around the region. The Asian Network of Occupational Hygiene [ANOH] has addressed this situation with a series of training courses within the region.

**Methodology**: Through its network of members, ANOH has been able to establish and implement an on-going Training programme in the Basic Principles of Occupational Hygiene [BPC], in several Asian destinations. ANOH uses a pool of volunteer, Occupational Hygiene accredited trainers, providing OHTA/BOHS certified courses, in collaboration with local practitioners, at no cost to the course participants. The local OH&S society identifies course participants and location - each course is limited to twenty [20] participants.Courses are assessed to International standard and lead to further, advanced technical training.

**Results**: The courses already completed have an examination success rate of greater than 85%. This presentation deals with the issues involved with the development of ANOH plans for Training and Professional development, within its sphere of influence.

**Conclusions**: Via the use of its technical resources pool, ANOH has an opportunity to significantly increase the technical base of Occupational

Hygiene, both practice and knowledge, as well as potentially offering international certification at zero or very low cost to participants.

*Keywords*: Occupational/Industrial Hygiene, Training, Accreditation

# Landslide risk assessment based on gis and remote sensing technology in Hoa An district, Cao Bang province

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**Abstract:**

Hoa An district in Cao Bang province is known for its important mountainous landscape area for developing geological, geomorphological, and biodiversity values, with economic, scientific, educational, and awareness-raising values for the Earth's geological heritage of Vietnam. However, due to its location in an area where geological and human activities are always strong in high mountainous areas, various disasters in the area along traffic routes, such as landslides and landslides on roads and works, are always at risk of occurring. In addition, due to the impact of climate change and the intensity of floods, the risk of such disasters may occur with increasing frequency and intensity. The study uses remote sensing imagery and logistic regression models to assess the factors and risk of disasters. The analysis results show that the main factors causing disasters are terrain slope, rainfall, and land use changes, and forecast the likelihood of disasters from low to high. Identifying the factors and zoning the risk of disasters occurring helps to plan the natural geological heritage area that needs to be protected, ensuring the development of economic, scientific, and educational values for the protection of special environmental landscapes.

*Keywords:* AHP, GIS, Ha Long

# Suitability assessment of land change cover to the ecological conditions in Nam Mu River Basin of Lai Chau province, Northern Vietnam in climate change context

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**Abstract:**

The industrialization process, urbanization, and climate change during the recent decade caused land cover to change rapidly in the northern mountainous region of Vietnam. The area of construction works, hydroelectric dams, and planted forests have increased significantly, while grassland, wild shrubland, and agricultural land have decreased significantly. In this study, Sentinel-2 imagery was used to determine land use change, and a multi-criteria analysis method was used to evaluate the suitability of land cover change to ecological conditions in the Nam Mu River Basin of Lai Chau and Son La provinces, Northern Vietnam in a climate change context. Obtained results prove some land cover changes are proper to the River basin's ecological conditions while others cause disadvantages for both wildlife and human life.

*Keywords*: land cover change, suitability, ecological condition, Sentinel-2 imagery, multi-criteria analysis method.

# Closing the Gap of Qualified OH Professionals through Changes to the IOHA NARC Assessments of National Associations.

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**Abstract:**

Since 2003, the IOHA National Accreditation Recognition (NAR) Committee has been evaluating the credentialing programs and supporting national associations developing their own certification programs for members. Currently, there are 18 credentialling national associations and organisations. However in Asia there are only 3 national associations accredited with 103 certified occupational hygienists. The presentation will discuss the challenges of the current numbers of certified occupational hygienists, the NAR accreditation assessment criteria and how national associations may help grow their numbers and close the gap.

Asia is the power house of global manufacture and as national education standards continues to grow, the expectations of a safe work environment and the protection of worker's health becomes more important. These changes also require a growing number of competent occupational hygienist in establishments such as the government inspectorate, companies, academia and consultancy.

The NARC has recently updated the criteria used to assess the certification programs to reflect the changing world in occupational health and hygiene. The criteria used to assess the certification programs have been updated and particularly for Criteria 3 - Education requirements. There are two pathways offered. One for university graduates as described in the original assessment criteria. A second and new pathway has been introduced which will allow members to build up a personal portfolio based on OHTA courses as well as

other recognised training courses provided by certified occupational hygienists or experts in the field. The number of years of experience will be increased to a minimum of 7, and determined by the national association.

# OHTA - Changing the World of Occupational Health and Hygiene One Course at a Time

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**Abstract:**

The Occupational Hygiene Training Association (OHTA) was formed in 2009 with the goal of improving worker health protection in the developing and developed world through training in the basic rubrics of occupational hygiene. Through the generosity of volunteer professional hygienists, many being subject matter experts, the international group developed eight courses with Student manuals and Trainers teaching materials. The first OHTA website for these documents was funded by the partnership of AIOH, AIHA, BOHS and IOHA.

All documents are free of charge to everyone worldwide and courses are taught by Approved Trainers (AT) who are certified occupational hygienists. The OHTA courses are a foundation for occupational hygienists to grow their careers into certified occupational hygienists, especially where other academic programs are not available. OHTA is developing the next generation of occupational hygienists.

After 12 years of offering courses through our global network of ATs, over 12,000 international students have completed at least one course, and the number continues to grow.

OHTA has grown with greater involvement from IOHA member associations, to ensure a sustainable rate of growth for OHTA and its outreach. Today there are over 35 member associations as well as WHWB supporting OHTA.

Our ATs are committed to improving occupational knowledge.

In recent years, more ATs have joined from the new national associations within IOHA to run courses for their members. These start the training pathway for their member's careers and ability to make a difference in their respective countries.

OHTA demonstrated its ability to respond to the changing world when it introduced on-line training during the COVID period. Courses continued globally, and at one course alone, twenty delegates from fifteen locations throughout the Kingdom of Saudi Arabia (KSA) attended and passed the W201 Basic Principles course in 2021. The photograph shows some of the students proudly displaying their OHTA certificate.

In 2023, OHTA updated all the training materials on the website from the original 2010 material and upgraded the website using innovative technology to build its own learning management system. This allows OHTA to now develop its own MCQ exams and we thank BOHS for their support with the original exam structure. The online MCQs allow the exams to be easily completed and students can access their results and certificates online. In the future, the MCQs will be translated to improve the demographics of training courses where English may not be the student's primary language.

The modern technology used by OHTA will allow more flexibility and innovation in developing courses for the changing world of diseases, manufacture and health hazards. Industry specific courses for mining, oil & gas, and pharmaceutical industries will be available.

The OHTA volunteer teams are excited about the new training opportunities, supporting the careers and growing numbers of occupational hygienists to address future health challenges in our changing world.

*Keywords:* Occupational Hygiene; Training; Competency Framework

# Occupational Health and Safety - Management of a Large College's OHS Program

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**Abstract:**

Every workplace has its own set of hazards, even if they aren't as obvious as those on a construction site or in a manufacturing facility. La Cité College, a large trade school with two main campuses, offers over 140 study programs. These programs range from first responders and health and biomedical sciences to television and audiovisual arts, architecture and engineering, computer science, accounting, and more. The college serves over 8,000 students and employs 1,500 staff members.

This presentation will focus on the occupational health and safety aspects of operating a large college. Managing and safely operating such a diverse and extensive facility presents unique challenges. Ongoing large-scale renovations must be handled with care to ensure the safety of students and staff while minimizing disruptions to college operations. Additionally, incorporating sustainability and resiliency into all operational aspects, particularly health and safety, is crucial and requires careful consideration.

*Keywords:* Occupational Health; College ; Management

# Occupational Lung Disease Prevention & Diagnosis

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**Abstract:**

Occupational Lung Diseases (OLD) are among the top three causes of worker deaths and DALYs, along with cardiovascular disease and cancer. This presentation covers general areas of understanding OLD presented over two consecutive 15-minute sessions:

**Session 8.1. Workplace controls and diagnostic tools**. This session covers essentials of primary prevention, medical surveillance and diagnostic spirometry, oximetry, imaging. The purpose is to become familiar with: a team approach to effective prevention of the full range of OLD conditions using strategies at the primary (safety and hygiene) level of controls for exposure risk mitigation; secondary medical surveillance and biological monitoring for early disease risk detection; and tertiary diagnostics for early onset symptoms, treatment and safe return-to-work or specialist referral. Key is realization of the benefits of safety, hygiene and worker-management collaboration partnering with nursing and medical professionals for worker protection, the trending and tracking of cases and public health reporting so that resources can be directed to drive down the global burden of OLD.

**Session 8.2. Common conditions and novel issues.** This session view briefly looks at lung conditions resulting from exposure to dusts, chemicals, metals and pathogens: asthma, hypersensitivity pneumonitis, byssinosis, fungi, and mineral dust pneumoconiosis due to asbestos, coal, silica, beryllium. The goal is to understand the disease process resulting from exposure at work, and the medical preventive approach. Knowledge of these diseases typically helps to inspire and drive primary prevention to save lives and drive down the burden of disease in terms of disease, disability,

productivity loss, and costs. Some novel aspects are touched upon: nanoparticles, climate-driven wildfire smoke, and infectious agents leading to pandemic or epidemic work-related lung disease. The future of mobile spirometry and chest imaging coupled with artificial intelligence (AI) applications to diagnostics and epidemiology is addressed briefly.

# Assessing the Feasibility of Reusing Gloves in Occupational Settings

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**Abstract:**

Hairdressers often rely on gloves to prevent dermal contact with chemical hazards, and due to cost or convenience, they may reuse them. This study aimed to evaluate the protective performance of neoprene and natural rubber latex (NRL) gloves when reused and decontaminated between exposures.

Neoprene and NRL gloves were tested against key ingredients in hair dyes, specifically p-phenylenediamine (PPD) and aminophenol isomers (m-aminophenol, o-aminophenol, p-aminophenol). Permeation tests were conducted according to the ASTM F739 standard, simulating continuous exposure for eight hours per day. After each exposure, gloves were decontaminated with detergents and water or water only. This process was repeated over five-day cycles, with each cycle conducted in triplicate. The samples collected were analyzed using gas chromatography with a flame ionization detector (GC-FID). Key performance metrics included breakthrough time (BT), cumulative permeated mass (CPM), and the 8-hour average permeation rate (PR). Factors influencing glove performance were analyzed using linear mixed models (LMMs).

No chemical permeation was observed in neoprene gloves during the first two days of exposure. In contrast, all tested chemicals permeated NRL gloves within the initial 8-hour period. Following the initial breakthrough, chemicals permeated earlier and faster, with a larger CPM in subsequent re-exposures. LMM analysis revealed that repeated exposure significantly affected protection efficiency, while different decontamination methods had no substantial impact on glove performance.

Hairdressers should be cautious about reusing gloves. NRL gloves are not recommended for handling hair dyes. Neoprene gloves showed no breakthrough for two days but may not be suitable for prolonged tasks. Simple water surface decontamination is advised if reuse is unavoidable.

# Efficient engineering controls for airborne diseases

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**Abstract:**

During the COVID-19 pandemic, billions of people are confined to their homes, wearing masks and maintaining physical distance to contain the worst infectious disease of modern times. Economic activity fell sharply, people lost jobs, and industries reached a standstill. The World Health Organization and the National Centers for Disease Control and Prevention have adopted almost all control measures based on hierarchical control principles, in addition to biomedical tools such as vaccines and antiviral drugs. As a result, the pandemic continued to spread, indicating that these measures were ineffective. Therefore, source-, pathway- or receptor-based controls must be redesigned to improve performance to 100%.

Control devices should be used according to the wearer's health status and the dispersion condition of the bioaerosols. Breath-taking hoods are designed for infected and asymptomatic people to remove the exhaled aerosols and protect the environment. Critical ill patients can use portable medical quarantine hoods when negative isolation wards are unavailable. Walk-in hoods with filtered incoming or outgoing flow for dining or other activities can be used by healthy or infected people, respectively. The Breath-Responsive Powered Air Purifying Respirators are designed to protect healthy people. Indoor air purifiers with adequate Clean Air Delivery Rates should be used to reduce health risks. Aerosol-free toilets are also essential in the overall control scheme.

Like a fire extinguisher puts out a fire that is still a spark, these novel and efficient engineering control tools can stop a pandemic at the beginning or sometime after it occurs. If not, they will help reduce infection rates, which will help prevent the healthcare system from collapsing and allow infected people to receive better care.

# The characteristics of using protection against the impact of noise by freelance workers at some intersections and crossroads in Thai Nguyen city

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**Abstract:**

Background: Intersections are the most complex part of the road transport network with relatively higher residential areas and complex traffic flows, resulting in higher traffic conflicts, delays and higher traffic noise pollution. Long-term exposure to traffic noise has negative health effects. Based on data reported in 2017, it is estimated that at least 18 million people are highly annoyed and 5 million people suffer from sleep disturbances due to long-term exposure to traffic noise in Europe

Methodology: A cross-sectional descriptive research method on 212 freelance workers at traffic intersections in Thai Nguyen city from April 2023 to April 2024

Results: The proportion of workers using protective equipment to limit the impact of noise is 43.4%, the remaining 56.6% do not use any protection; 31.5% use hats that cover the ears, 22.8% use earplugs and 21.7% use ear caps.

Conclusions: Advise workers on the importance of using protective gear to prevent the effects of noise, especially in places with high sound pressure levels; Advise workers to participate in annual health check-ups.

*Keywords*: Thai Nguyen, freelance worker, noise

# Sampling Solutions in Welding Operations in Manufacturing and Construction Workplaces

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**Abstract:**

Welding operations in manufacturing and construction workplaces present significant occupational hazards due to the release of toxic gases, including Carbon Monoxide (CO), Nitrogen Dioxide (NO2), and Ozone (O3), as well as harmful airborne particulates. These particulates contain metal fumes, often laced with dangerous elements such as manganese and hexavalent chromium, which pose substantial health risks. Extended exposure to these fumes can cause severe respiratory conditions, and more critically, the International Agency for Research on Cancer (IARC) has categorized welding fumes as Group 1 carcinogens, indicating confirmed evidence of their carcinogenicity in humans.

The critical health risks linked to welding necessitate thorough air quality monitoring within such workplaces. Several methods exist for real-time detection and sampling of hazardous gases and particulates. These include active sampling techniques, where air pumps collect and concentrate airborne toxins for analysis, and passive sampling techniques, which rely on diffusion to capture vapors without mechanical sampling pumps.

This paper focuses on the array of sampling solutions offered by SKC for welding operations, underscoring the vital role of appropriate monitoring equipment in mitigating exposure to harmful substances. Key solutions include air sample pumps, passive and active samplers, sample bags, filter cassettes, and sorbent tubes, each designed to meet rigorous agency standards and sampling protocols. Furthermore, innovative sampling techniques tailored for welding environments are highlighted, providing essential tools to

safeguard worker health.

By utilizing such advanced equipment, industries can maintain compliance with safety regulations while minimizing the health risks associated with toxic exposure. These sampling methods are crucial to ensuring that welding environments remain safe, ultimately reducing the long-term occupational hazards linked to welding fumes.

# Assessment of Styrene Exposure among Workers in Manufacturing Facilities Using Styrene as a Raw Material

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**Abstract:**

Styrene, an unsaturated aromatic hydrocarbon, is widely used in various industries, particularly in the production of plastics and composites. However, prolonged exposure to styrene can lead to severe health consequences, including respiratory and neurological disorders. This study, conducted on 986 workers in 8 manufacturing facilities from 2021 to 2022, aimed to evaluate the level of styrene exposure and its impact on workers' health. Results revealed that 23 out of 986 workers (2.3%) exhibited urine MA&PGA levels exceeding the American Conference of Governmental Industrial Hygienists (ACGIH) permissible exposure limit (>400 mg/g cre), with 22 of these cases occurring in plastic manufacturing facilities and one in a synthetic rubber facility. Among the 37 workers in the artificial quartz stone manufacturing sector, 13 (35.13%) had urine MA&PGA levels twice the ACGIH permissible limit, with an average concentration of 813.83 ± 271.88 (mmg/g cre). Notably, the mean urinary MA&PGA levels were significantly higher in the exposed group compared to the control group (p=0.015). Furthermore, a positive correlation was observed between age and urinary MA&PGA levels. The linear regression model indicated that for every one-year increase in age, the MA&PGA level increased by 2.09 units (Coef = 2.09; 95% CI: 0.54-3.46). These findings underscore the significant health risks faced by workers in styrene-related industries, necessitating urgent measures to safeguard their well-being.

*Keywords*: Styrene, exposure,  occupation health, worker.

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