APPLYING NUCLEAR ENGINEERING TO STUDY HEAVY METAL POLLUTION IN THE AIR IN HO CHI MINH CITY

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Abstract:

Emissions from traffic activities are known as the main source of air pollution in urban areas in Asia., Ho Chi Minh City, Vietnam has many vehicles causing gas pollution. The goal of this study is an overview of the methods nuclear techniques can use to assess the level of heavy metal pollution in the air. The study then assessed the current state of heavy metal pollution in the air in Ho Chi Minh City. Finally, the study recommends that future studies should use nuclear techniques to assess the level of heavy metal pollution in the air.

Keywords: Particle Engineering, Heavy Metal Pollution, Air

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1. Introduction

Air pollution is an increase in the content of toxic substances in the air. Air quality has a major impact on human health, especially for those with low collection and in vulnerable groups such as the elderly and children. According to estimates by the World Health Organization (WHO), exposure to polluted air causes 6.5 million premature deaths worldwide. Nearly 90% of these cases occur in low- and middle-income countries, and nearly two-thirds in the Asia Pacific region.

According to a report by the international organization IQAir in 2019, Vietnam ranked 15th in the list of countries and territories with the worst air quality in the world and second in Southeast Asia after Indonesia in 2019. Hanoi has become the capital with the 7th most severe PM2.5 pollution level in the world, even above Beijing, with an average PM2.5 level of 46.9 µg.m-3 [1], while the concentration according to the National Weather Service for ambient air quality is 25 μg.m-3. Without effective response measures, air quality is expected to continue to deteriorate in the future due to the effects of rapidly growing polluting economic activities.

The state of urban air quality in Hanoi or Ho Chi Minh City makes people always ask the question "in the end, what are those pollutants besides fine dust", "can pollution moments and pollution hotspots be identified in each place"? Questions from that reality always make researchers ponder and spend time learning to try to get the most authentic answers. Most current air quality research focuses on the size and distribution of PM2.5, PM10 or NOx and SO2 emissions – important indicators of common air quality. The complex picture of air quality still leaves plenty of room for "new players" to step in and add a few equally important pieces of the puzzle – heavy metal pollution in the air and the adoption of a new method of using moss as a biomarker, instead of using sensors in monitoring stations or the usual passive and active sampling methods.

2. Literature review

2.1. Overview of air pollution

Air pollution occurs when the air contains toxic components such as gases, suspended dust, smoke, odors. In other words, changes in air composition, an increase in toxic substances in the air, causing discomfort or adverse effects on health and the environment. ONKK agents can be solid particles, liquid droplets or gases, including the two main types that are pollutants that enter the environment directly from the source of generation such as SOx, COx, NOx, dust, etc. called primary pollutants, and secondary pollutants are formed when primary pollutants react or interact with components of the environment field. ONKK has the risk of affecting human health and other components of the environment such as soil and water through the ecosystem cycle.

2.2. Consequences of air pollution

The fact that ONKK has extremely heavy consequences for both creatures and humans. Harmful gases such as SO2, CO2, CO,... when entering the atmosphere directly harms plants, damages the drainage system and reduces disease resistance. Most fruit trees are very sensitive to HF, when exposed to large concentrations of HF, the leaves will burn spots and shed their leaves. Global warming due to the greenhouse effect also causes changes to both animals and plants.

Acidic ONKK agents will combine with water droplets in the cloud to make the water acidic. When water droplets fall to the ground, it harms the environment, killing flora and fauna. Acid rain also changes the properties of water in rivers and streams, harming aquatic organisms. In addition, acid rain has an indirect effect on plants, killing living organisms inside the ground, releasing aluminum (Al) ions into water that harm plant roots, and reducing plant food and water absorption.

For humans, inhalation of air sources containing toxic metals in gas dust can lead to respiratory diseases, diseases of the eyes, skin, cardiovascular diseases and especially cancer. Large concentrations of SO2 and NO2 can cause increased mucus secretion in the upper respiratory tract mucosa and in the bronchial branches, affecting lung function, causing pneumonia, chronic bronchitis, cardiovascular disease, hypersensitivity in people with asthma, etc. Ammonia gas (NH3) and hydrogen sulfide gas (H2S) enter the body in large doses will causes sudden lack of oxygen, leading to death from asphyxiation.

Toxic KLN elements such as Pb, Cd, Zn, As, Hg, ... released into the environment from natural sources and human activity, they have highly toxic properties, causing harm to human health and the living environment.

2.3. Air pollution research methods

To assess the quality of the air environment, the most commonly implemented method today is online monitoring. An environmental monitoring station usually consists of the following components: Multi-indicator gas analyzer (SO2, NO2, O3, CO, Benzene, Toluene, Xylene, Formaldehyde, etc.); PM10, PM2.5 dust detector; Equipment for measuring microclimate factors (rain, wind, temperature, humidity, radiation); The system collects data and transmits data via ADSL or GSM to the center; The server system collects, stores and processes data using specialized software at the center. The measurement results of parameters specific to the air environment in general and TSP dust in particular are the final values at the receiving point. However, the fact that the number of measurement points is small or the number of measurements is not much, the frequency of measurement is low, the assessment based on the monitoring value does not show the overall picture of the air quality of the study area. On the other hand, the cost of equipment investment and operation, exploitation of the automatic monitoring system as well as training to receive sufficient experience in operating the system is not an easy problem to solve.

Modeling methods, applications of GIS technology provide information and means to evaluate and analyze polluting factors from different types of waste sources, factors affecting the environment more effectively, actively supporting management, protection of air pollution.

2.4. Heavy metals and human health effects

Heavy metals are the term used to refer to metals with a density greater than 5g.cm-3, have a high atomic number and usually exhibit metallicity at room temperature. KLN is divided into 3 types: (1) toxic metals (Hg, Cr, Pb, Zn, Cu, Ni, Cd, As, Co, Sn,...), (2) precious metals (Pd, Pt, Au, Ag, Ru,...), (3) radioactive elements (U, Th, Ra, Am,...). KLN is widely used in a number of industries, agriculture, medical and engineering applications. In elemental form, KLN is not harmful, but when it exists in ionic form, KLN is very toxic to human health when exposed at very low levels.

Worldwide metal emissions into the atmosphere (thousands of tons per year) according to natural sources are estimated to be Ni(26), Pb(19), Cu(19), As(7.8), Zn(4), Cd(1.0), Se (0.4) (units: tons × 106. year-1). Meanwhile, from artificial sources Pb (450), Zn (320), Ni (47), Cu (56), As (24), Cd (7.5), Se (1,1) (unit: ton 10 3 year-1). From these numbers, it is clear that Pb, Zn, As, Cd and Cu are the most important contaminated metals from human activities. The main metals of interest listed by the United States Environmental Protection Agency are Al, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Se and Sb. These metals are of interest due to their high toxic properties, their effects on the environment and living organisms, the possibility of human contact and increased health risks.×

2.5. Dispersion of heavy metals in the environment

KLN is involved in the biogeochemical cycle: the flow of nutrient chain elements in which the first link is a plant, the second enters the animal's body, and the last is represented by metals that move to the next cell, often leads to increased cell content and partial accumulation of them in the cell. The amount of KLN taken from the soil by the plant root system mainly depends on the degree of accumulation of individual elements in the soil and the ability of the soil to fix the adsorption complex. The adsorption capacity of the soil is determined by the quantity and quality of colloids in the soil that form the sorbent complex. As soil pH and the content of floating particles (mainly colloidal clays) and organic matter (especially rotting matter) increases, the availability of KLNs to crops is reduced.

On the other hand, long-range atmospheric transport and pollution of KLN is a process of transport and atmospheric accumulation of KLN of air [26]. Many KLN contained in human-caused contaminants such as industrial organic matter, pesticides and trace metals have been widely distributed across the globe. Even the most remote areas may not be outside the range of pollutants emitted by man-made sources.

3. Atomic nuclear analysis techniques

Neutron-gamma delay analysis technique (INAA)

Neutron activation analysis (INAA) was first introduced in the world in 1936. So far, this method has a long history and contributed a significant part to the development of science and life. The basis of the INAA is based on the reaction (n,γ) to the deep penetration of neutrons to matter and the ability of unstable nuclei to emit delayed gamma rays made up of the reaction (n,γ). Based on these properties, the standard sample and the analytical sample are stimulated simultaneously under the same conditions, after which the emitted signals of both can be measured after an appropriate time.

To perform an elemental analysis using INAA, a neutron radiation source, gamma radiation recording equipment, a clear understanding of the processes of nuclear reactions as well as decay of product nuclei, mastery of methods for identifying and determining the content of elements of interest as well as performing the necessary calibrations. The best commonly used source of radiation is the thermal neutron beam from the reactor. The ultrapure gamma gamma spectrometer (HPGe) system is commonly used to record the gamma spectrum of activated samples. The energy of the gamma rays emitted during decay and half-life is specific to each nucleus, so they are used to identify the elements that participated in the reaction. The content of such elements is determined based on the intensity of the characteristic gamma rays emitted by the isotopes of this element. INAA technique has fast speed, sensitivity, high accuracy, non-destructive samples, stable analysis results. Therefore, it is widely applied in elemental analysis, testing, material evaluation, environmental control.

X-ray emission analysis technique caused by proton beams (PIXE)

PIXE uses a beam of high-energy protons emitted by the accelerator to project into the sample to be analyzed to stimulate specific X-ray emitting elements. The characteristic X-ray emission process includes: protons will interact and ionize the beer atom by Coulomb interaction that turns electrons in layers deep inside the atom, creating holes. Next, an electron from the outer layer will jump in to fill that hole, which will release energy in the form of electromagnetic radiation (X-rays) whose energy is equal to the difference in energy between the two shells, which are X-rays that characterize atoms and can be used to identify that atom. Recording the energy and intensity of these X-rays allows guessing which element is present in the sample to be analyzed and its content. This method is usually performed on electrostatic accelerators.

The advantages of the PIXE technique are multi-elemental analysis, high sensitivity due to the large X-ray emission performance and small braking radiation font, capable of analyzing very small samples, if using the absolute method, there is no need for standard samples, fast, non-destructive and economical. It has been used and applied in many applications of elemental analysis in fields such as materials, medicine, biology, geology, atmospheric pollution, etc.

Fully reflective X-ray fluorescence analysis (TXRF) technique

The TXRF method is a very effective multi-element analysis technique that allows rapid analysis of elemental composition with a small sample size. The principle of the method is to use an X-ray emission source (usually an X-ray tube) to excite the atom to emit X-rays characteristic of elements, based on the recording of the reflected X-ray spectrum we can identify and determine the content of the elements present in the sample. TXRF is an improved technique of conventional X-ray fluorescence (XRF), which allows the analytical sensitivity to be increased by several orders of magnitude and thus the elements in the sample can be detected at trace content levels. TXRF minimizes the influence of background effects commonly encountered in traditional XRF techniques.

4. Use nuclear techniques to study heavy metal pollution in the air in HCM City

4.1. Usable nuclear techniques

Atomic absorption spectroscopy (AAS)

The AAS method is based on the principle that when an atom exists freely in a gaseous state and in a fundamental energy state, the atom does not acquire or emit energy. When projecting into the free atomic vapor a monochromatic beam of light of a suitable wavelength, which coincides with the emission spectral wavelength characteristic of the analytic element, they absorb that ray giving birth to a kind of atomic spectrum. This spectrum is called the absorption spectrum of the atom. The basis of quantitative analysis according to AAS is based on the relationship between spectral line strength and element concentration to be analyzed. The atomic absorption spectroscopy method has the advantages of sensitivity, high accuracy, low sample consumption, fast analysis speed. AAS is often used as the standard method for determining small amounts and trace amounts of metals in a variety of objects. AAS spectrometry can analyze trace amounts of most metals and also organic compounds or anions that do not have atomic absorption spectroscopy. It is widely used in the following industries: geology, chemical industry, petrochemicals, medicine, biochemistry, pharmaceuticals.

Atomic Emission Spectroscopy (AES)

In principle, the AES method is based on the occurrence of the emission spectrum of the free atom of the analytic element in a gaseous state when there is an interaction with the appropriate energy source. AES has a very high sensitivity usually from n.10-3 to n.10-4%, especially if the excitation source is ICP, the sensitivity can be up to 10-6%, the sample amount is small, it is possible to analyze many elements in the same sample simultaneously. AES is often used to test and evaluate chemicals, pure raw materials, analyze the amount of toxic metal ions in water, food, and food.

ICP-MS mass spectrometry method

The ICP-MS (Inductively Coupled Plasma Mass Spectrometry) method is a technique for the analysis of inorganic elements, the principle of quantitative analysis is based on measuring the ratio of m / z (number of masses / charge) of positive ions generated by the energy of the induced plasma lamp. Under the effect of high temperature, the atoms will switch to the excited state, breaking away 1 electron to become a positive ion. The plasma medium consists of discharged Aratoms. Argon can ionize the vast majority of other elements with ionization energies in the range of 4 - 12 eV. ICPMS with a wide variety of applications is widely used in the world, about 80% of analyses now use ICP-MS. The advantage of the ICP-MS method is that it is capable of rapid multi-element analysis at ultratrace content with high sensitivity (ppt detection limit, equivalent to ng / L), with a very wide linear area (size from 0.5 ppt to 500 ppm); the wide range of mass analysis (from 7 amu to 250 amu) should analyze most elements from Li to U; There is also the possibility of analyzing isotopes of the element (due to the fact that isotopes have different masses). Another advantage of the ICP-MS method is the fast sample analysis speed, for cases where mass analysis of elements is required, it only takes 3-5 minutes.

4.2. Assessment of heavy metal pollution in the air in HCM City

HO CHI MINH CITY is one of the big cities of Vietnam, where there are many industrial parks, export processing zones and many large and small companies, so it can be said that Ho Chi Minh City. HCM is the most densely populated place across the country. Because of this, the atmosphere here is increasingly polluted to an alarming level, especially at the end of the year because the works and companies accelerate the construction schedule, causing more and more emissions and smog into the environment.

Due to the large population concentrated in Ho Chi Minh City HCM city has caused this city to appear air pollution waves that are at an alarming level. In Ho Chi Minh City HCM synthetic dusts are far above the standard by up to 2.2 times and this seriously affects human health. The most polluted air time is at night and early in the morning, the amount of fog in the sky is dense, making a lot of people worried.

HCM has days when the amount of PM2.5 fine dust increases very high, this fine dust is considered the silent killer and the most dangerous to health, it causes many deaths due to the appearance of problems in the respiratory system, cancer,..

The reason for the air pollution in Ho Chi Minh City HCM comes from the emissions from gasoline emitted by vehicles such as motorbikes and cars every day on the street. In addition, emissions and dust from export processing zones, industrial parks, construction works,.. also causing the air source in this city to be polluted to an alarming level.

5. Conclusion

Nuclear and radioisotope engineering can help us better understand the world we live in. Data collected through these techniques can serve as a scientific basis and improve policy making, including those related to climate change. Using nuclear techniques it is possible to study soil and water systems to assess the impact of climate change on the environment.

Nuclear and radioisotope techniques are effective tools in monitoring the emissions of greenhouse gases such as carbon dioxide (CO2), dinitrogen monoxide (N2O) and methane (CH4), studying changes in environment for oceans, mountains and their ecosystems, and assist in the development of adaptation measures to food and water shortages exacerbated by changing weather patterns. Nuclear Science and Applications, the International Atomic Energy Agency (IAEA), said: "Countries around the world are increasingly recognizing the value of using nuclear technology in dealing with these challenges. challenges posed by climate change and is exploring directly the benefits of technologies promoted by the IAEA." Using isotope techniques can help collect data to identify, monitor and manage sources of greenhouse gas emissions to understand how they are connected to changes on land, in the oceans and atmosphere. Using nuclear techniques it is possible to determine the exact amounts of isotopes and their ratios, with applications in traceability, history, isotope sources and their interactions in the environment. Through these measurements, experts can better understand the functioning of different ecosystems.

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