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ENVIRONMENTAL CHEMISTRY: MONITORING AND REMEDIATION OF POLLUTANTS IN AIR, WATER, AND SOIL

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Abstract

Introduction- The purpose of this study is to determine pollutants present in air, water, and soil. Highlighting the impacts of these pollutants and ways to monitor and control these pollutants are other objectives of this research. Further, air pollution, water pollution, and soil pollution are illustrated as a part of environmental pollution.

Literature Review- The increase in industries and vehicles drives the emission of these gases and causes air pollution. Different substances

including radioactive elements are found in industrial waste, especially power-generating industries. Dumping these wastes in waterbodies drops the quality of water and makes it polluted. Carbon monoxide, lead, nitrogen oxides, and sulphur dioxide are some critical air pollutants. The theory of Pollution Policy states manufacturing a product without waste is impossible.

Methodology- The theoretical analysis has been followed in this study to gain knowledge on pollutants in air, water, and soil. Further, interpretivism philosophy, inductive approach, and exploratory design have been used.

Findings and Analysis- Air pollution Monitoring and AERMOD are used to measure and monitor air pollutants. On the other hand, MIKE 21 and WASP are used to monitor pollutants in water and check water quality. Soil Quality Index helps in gaining information on pollutants present in soil. Reducing the use of fossil fuels, minimising the use of inorganic fertilisers, and optimisation of toxic waste are effective remedies to control these pollutants.

Discussion- From the above research, it can be stated that carbon dioxide, sulphur dioxide, carbon monoxide, and nitrogen oxides are harmful gases and lead, carbon, and sulphur are harmful particles that are key pollutants in the air. It is found that the use of renewable energy, biomass, and geothermal energy instead of fossil fuel is an effective remedy to control air pollutants.

Conclusion- Thus, it can be concluded that in each aspect of the environment, different pollutants are present that harm humans. Therefore, monitoring these pollutants in three crucial environmental components, air, water, and soil, and controlling these pollutants becomes essential.

Keywords: ***Air pollutants, water pollutants, soil pollutants, fossil fuel, industrial waste, inorganic fertilisers***

Introduction

Air, water, and soil are three key components of the earth and unwarranted disposal of these components causes environmental pollution. As per the statement of Long *et al.* (2021), the unfavourable alternation, generally made by humans on environmental components is defined as environmental pollution. In contemporary days, climate change is one of the critical consequences of increasing pollutants in environmental components. The increase in population drives industrialisation and the use of transportation (Mohajan, 2019). An increase in these factors causes the reduction of greenery and negatively impacts environmental components. In this study, air pollution, water pollution, and soil pollution are going to be illustrated as a part of environmental pollution.

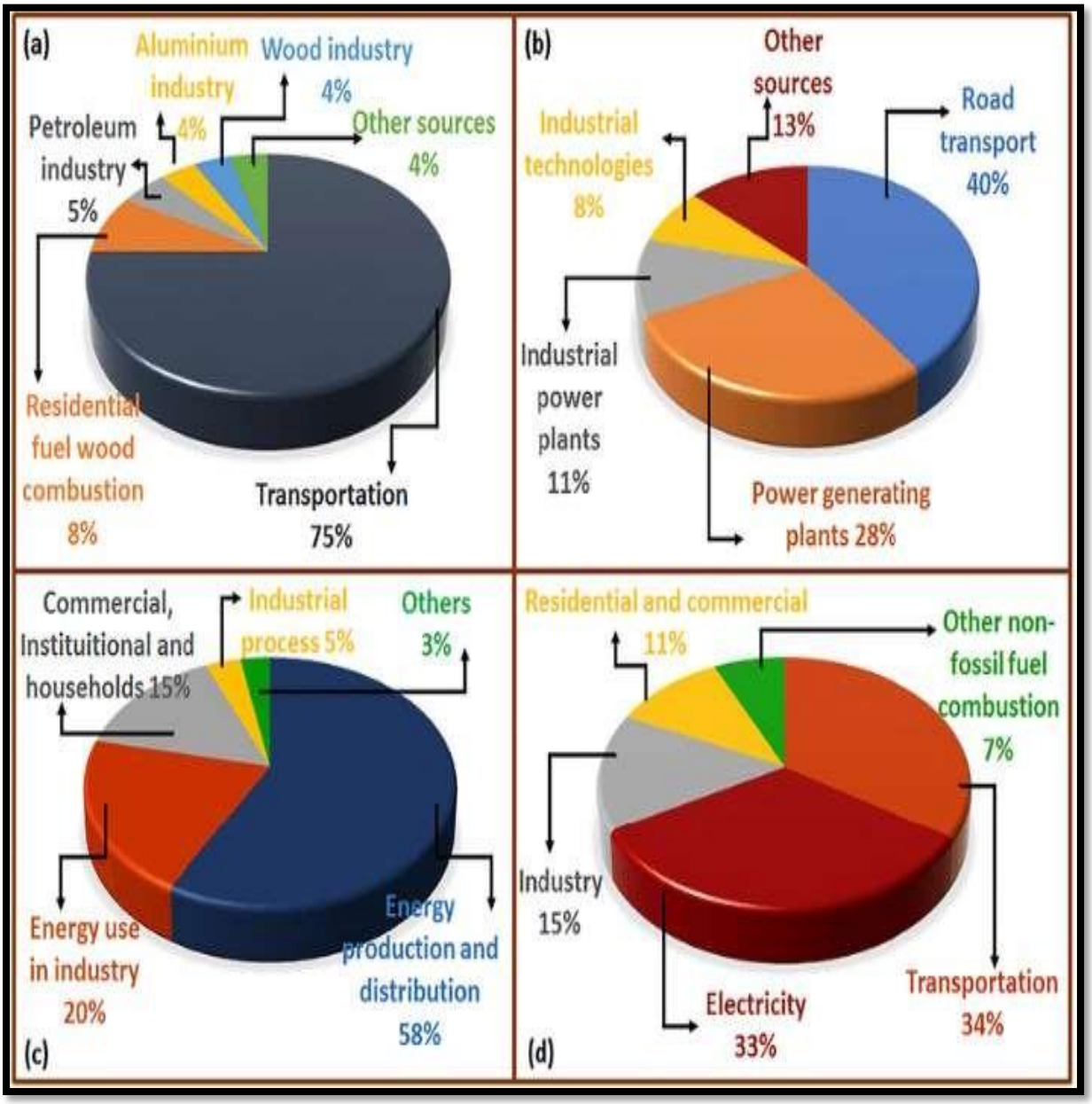

Figure 1: Pollutants in Air

(Source: Researchgate, 2023)

Air is a mixture of different gases, dust, and other particles. The air becomes polluted when harmful gases such as carbon dioxide (CO2), carbon monoxide (CO), nitrogen oxide (NO), sulphur dioxide (SO2), and many other harmful particles are mixed in the air (Gonzalez-Martin *et al.* 2021). According to above figure 1, CO is emitted from different vehicles used in transportation and NO is emitted from power-generating plants and road transport. Different industries emit SO2 and fossil fuels and vehicles are responsible for emitting CO2 in the air. Cardiovascular diseases, cancer, asthma, and chronic obstructive pulmonary disease (COPD) are major consequences of air pollution.

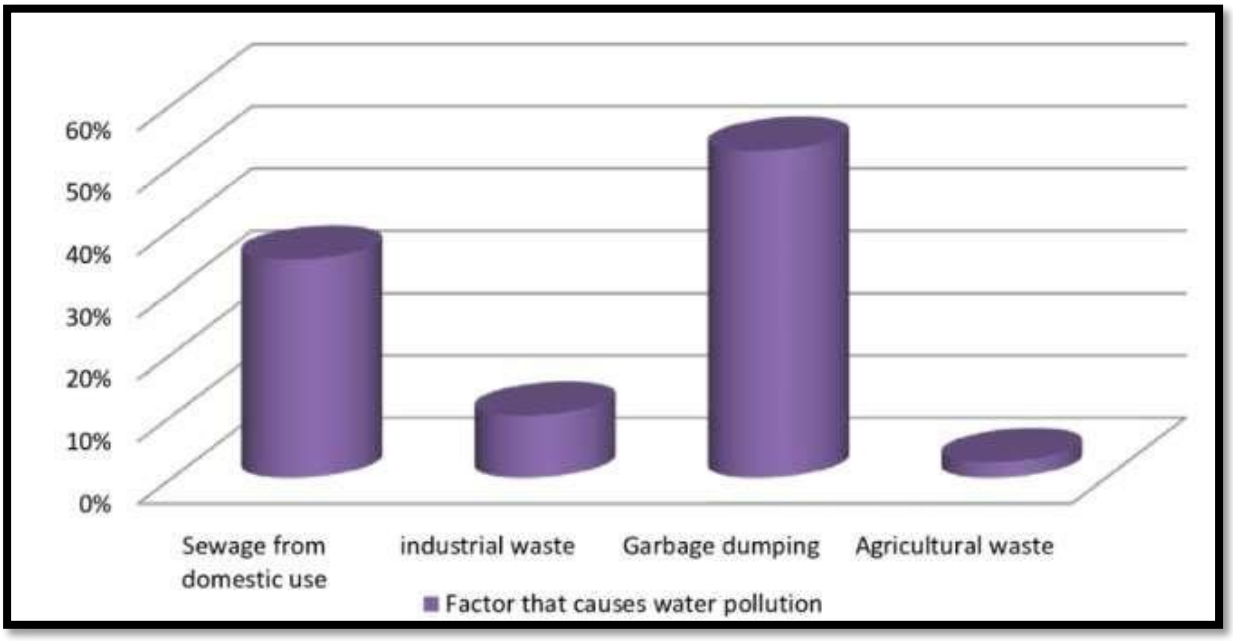

Figure 2: Water Pollution

(Source: Researchgate, 2023)

Substances which drop the quality of water and make it unusable for drinking and other activities are referred to as water pollutants. As per the findings of Zhang *et al.* (2021), these pollutants cause water pollution and it is seen that industrial waste, garbage dumping in water, sewage, and agricultural waste mainly cause water pollution. According to the bar chart represented in figure 2, garbage dumping pollutes water by about 55%. One of the critical impacts of water pollution is noticed in the destruction of marine biodiversity (Srivastav & Ranjan, 2020). Besides this, drinking polluted water causes different diseases such as diarrhoea, cholera, hepatitis A, typhoid and many others.

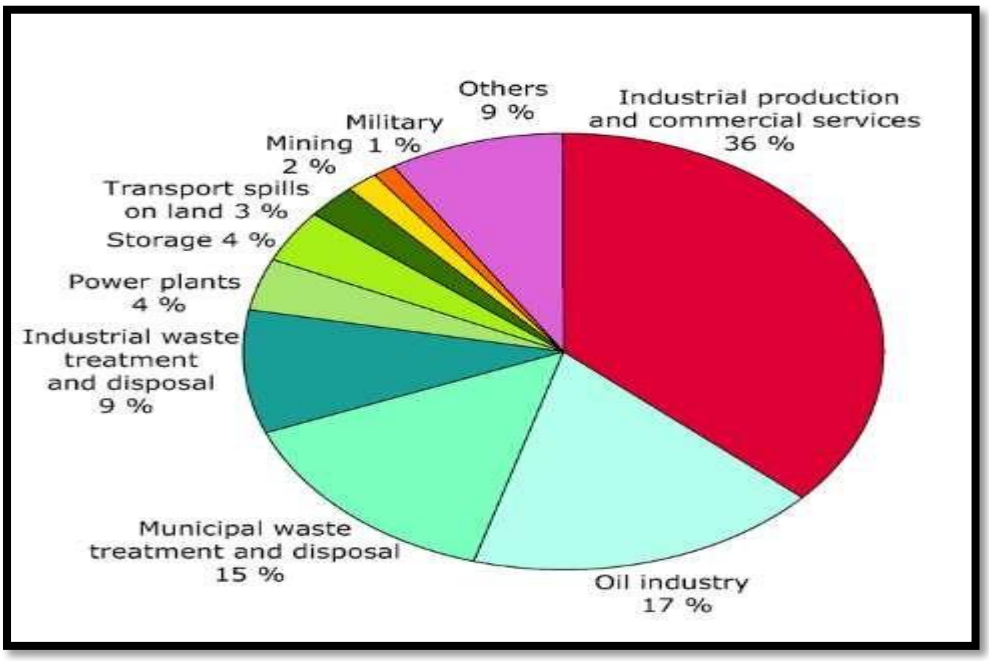

Figure 3: Economic activities cause soil pollution

(Source: Eea.europa 2023)

According to figure 3, industrial production causes soil pollution by 36% followed by the oil industry and municipal waste disposal. The loss of soil fertility is the common result of solid contamination (Zwolak *et al.* 2019). Since these pollutants are associated with high risk factors, monitoring and controlling these pollutants become essential.

Aim

The primary aim of this research is to evaluate the presence of pollutants in air, water, and soil. The secondary purpose of this study is to find remedies to control these pollutants.

Research Objectives

RO1: To highlight the current value of pollutants, present in air, water, and soil

RO2: To understand different models such as APM, MIKE 21, and Soil Quality Index that are used to check the quality of air, water, and soil

RO3: To illustrate factors that cause the increase in pollutants in air, water, and soil

RO4: To find out remedies which are effective in controlling pollutants present in air, water, and soil

Research Questions

RQ1: What is the current condition of pollutants present in air, water, and soil?

RQ2: How APM, MIKE 21, and Soil Quality Index are useful in checking the quality of air, water, and soil?

RQ3: Which factors cause the increase in pollutants in air, water, and soil in contemporary days?

RQ4: Which remedies are effective in controlling pollutants present in air, water, and soil?

Literature Review

Current scenario of air, water, and soil pollutants

Current status of air pollution

In contemporary days, the increase of industries and use in transportation drives air pollution. Carbon and sulphur are two particles that mainly cause air pollution. Carbon is emitted in the air by carbon dioxide and carbon monoxide and sulphur are emitted in the air in the form of sulphur dioxide (World Health Organization, 2021). The increase in industries and vehicles drives the emission of these gases and causes air pollution. Due to the exposure to air pollution, about 6.7 million people face premature deaths annually (Who, 2023).

Current status of water pollution

The number of bacteria, viruses, and parasites make a water body polluted. As per the findings of Al-Taai (2021), fertilisers and pesticides used in agricultural fields mixed in the nearby waterbodies and cause water contamination by increasing the growth of bacteria, viruses, and parasites. Further, different substances including radioactive elements are found in industrial waste, especially power-generating industries. Dumping these wastes in waterbodies drops the quality of water and makes it polluted. It has been seen that due to the increase in water pollution, about 2 billion people which stands for 26% of the total population fail to get safe drinking water (Unesco, 2023).

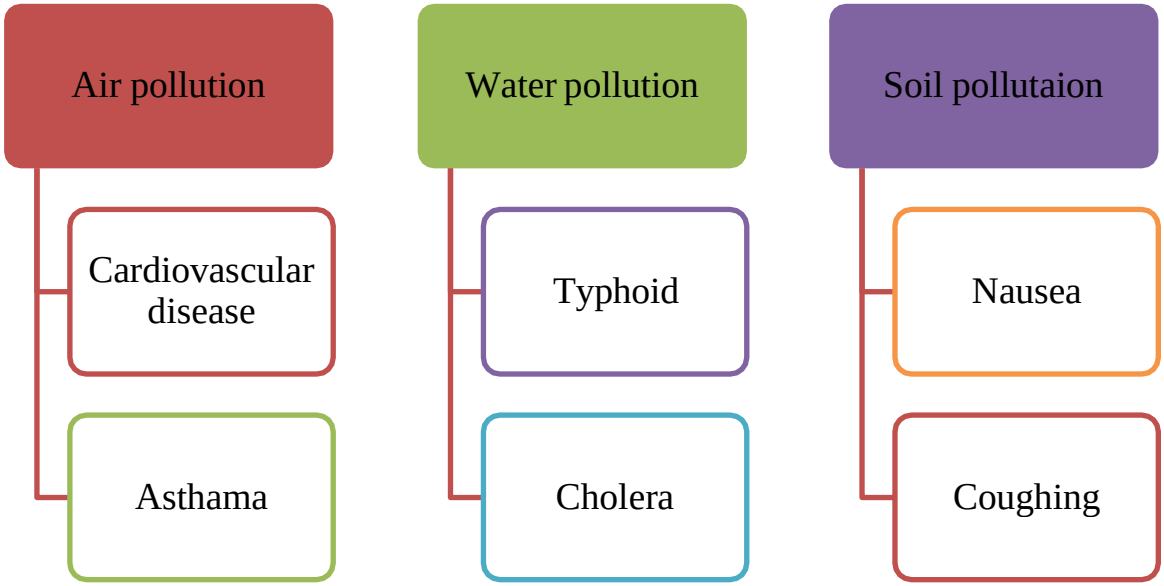

Figure 4: Different types of environmental pollution

(Source: Influenced by Long *et al.* 2021)

Current status of soil pollution

In current days, soil pollution has become the key threat towards the ecosystem globally. As per the comment of Baweja, Kumar & Kumar (2020), the use of excessive inorganic fertilisers and pesticides, cutting trees down, and dumping non-biodegradable waste like plastics cause soil pollution. Due to exposure to soil pollution around 500,000 premature deaths occur each year globally.

Factors causing air, water, and soil pollution

Air pollutants

According to the Centres for Disease Control and Prevention (CDC), carbon monoxide, lead, nitrogen oxides, and sulphur dioxide are some critical air pollutants (Cdc.gov, 2023). Excessive use of fossil fuel is one of the main reasons that drives the generation of air pollutants. Further, gases leak out from different industries, especially power-generation factories increasing the amount of carbon and sulphur identified as critical air pollutants.

Water pollutants

These air pollutants react with each other and other particles present in the air and cause acid rain. As per the words of Mandowara (2023), acid rain causes the loss of PH balance in waters which makes the water unusable and negatively impacts marine life. Further, industrial waste contains toxic elements that make water polluted and hence industrial waste is another crucial pollutant. According to the report of BBC, due to the release of toxic waste from the Nestle company, over tonnes of marine life were found dead in France (Bbc, 2023).

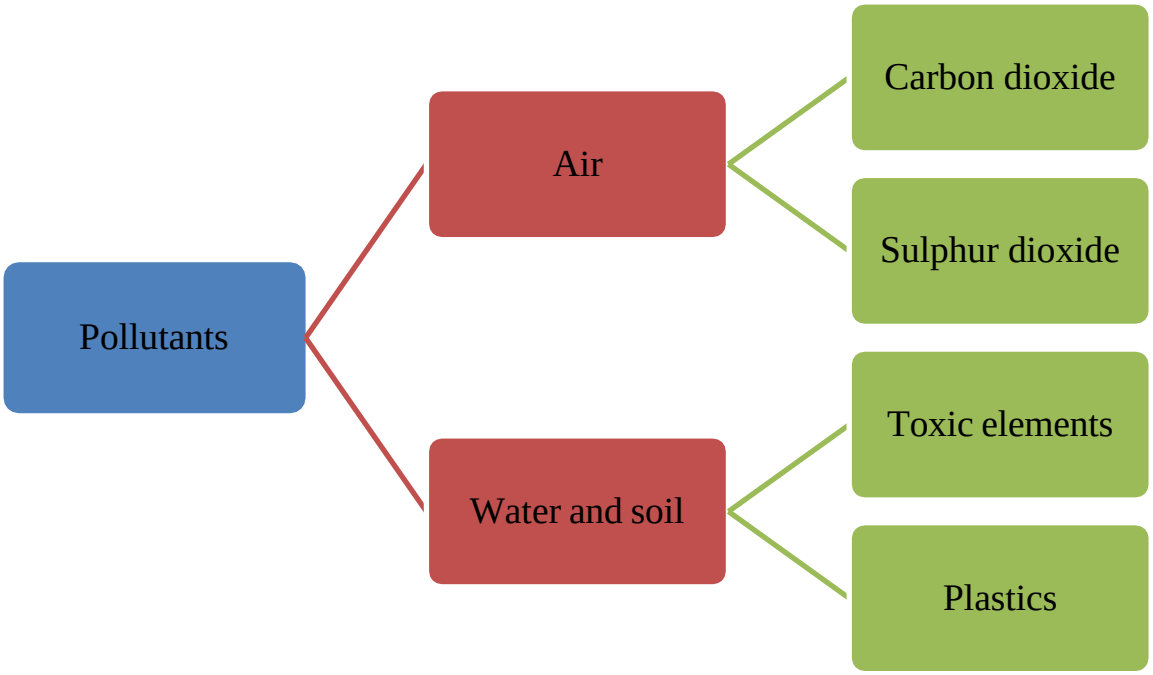

Figure 5: Air, water, and soil pollutants
(Source: Influenced by Mohajan, 2019)

Soil pollutants

Excessive potassium, phosphate, nitrogen, cadmium, sulphur, and carbon are the main soil pollutant elements (Abdelwaheb *et al.* 2022). The use of inorganic pesticides and fertilisers drives the amount of these elements in the soil. On the other hand, plastic below 75 microns thickness is not biodegradable and remains the same year after year. Hence dumping waste that includes plastic causes soil pollution and plastic is considered a vital soil pollutant.

Theoretical framework

Theory of Pollution Policy

According to the Theory of Pollution Policy, manufacturing a product without waste is impossible. The theory also states that excessive waste becomes pollutants and contaminates environmental components such as air, water, and soil. As per the notation of Kraft (2021), the theory of pollution policy points out the feasible solution of optimising the level of pollutants. According to the environmental chemistry, pollutants in air, water, and soil drops the life quality of human. The theory justifies the importance of controlling these pollutants and the generation of remedies to take these pollutants under control.

Literature gap

Not giving more numeric information in the literature caused a literature gap. Further, failing to go in-depth into the theoretical framework generates a theoretical literature gap. Apart from this, not to mention the impact of pollutants in air, water, and soil on the human body.

Methodology

The systematic procedure through which research is completed with sufficient information is defined as a methodology (Newman & Gough, 2020). The interpretivism research philosophy has been used to gain an in-depth understanding of the pollutants in air, water, and soil. As for research design and approach, the inductive approach and exploratory design have been conducted. These primary paths of methodology indicate the use of ***theoretical analysis*** in this study to discover how to monitor and control air, water, and soil pollutants. In such analysis, different models and statements are analysed to gain the desired result.

Findings and Analysis

Theme 1: APM and AERMOD in checking pollutants present in air

Pollutants in the air cause different critical diseases in human bodies including some chronic diseases. In order to monitor the pollutants, present in the air, ***Air Pollution Monitoring (APM)*** are used. As per the views of Azhahudurai & Veeramanikandan (2023), the deterministic association between emission and depositions of air pollutants can be quantified through APM. Besides this, these models are useful in illustrating the effectiveness of abatement approaches by considering past consequences and estimated future scenarios. With the help of APM, the quality of air can be described at a specific location at a specific time (Iitk.ac.in, 2023). In order to understand the specific atmospheric procedure which disperses pollutants, dispersion modelling is useful.

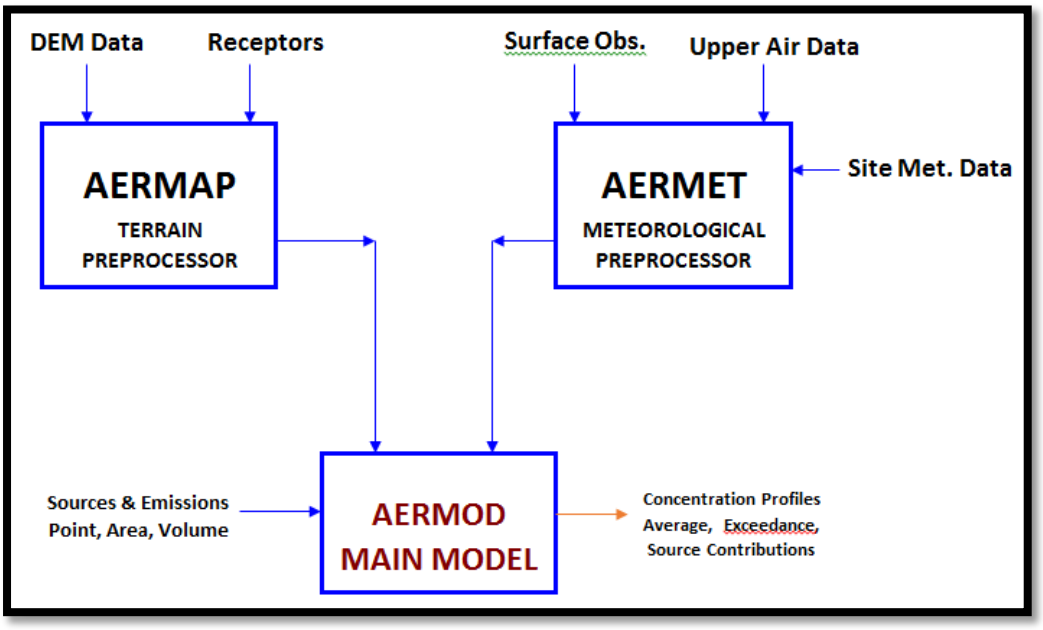

Figure 5: AERMOD Model

(Source: Influenced by Milošević *et al.* 2020)

With the help of emission reports and meteorological inputs, the AERMOD model creates a dispersion model of air pollutants (Epa.gov, 2023). Hence, it can be stated that the AERMOD model is a combination of AERMAP and AERMET procedures. In order to assess

pollution deposition and concentration across the world, the AERMOD model is used. As per the comment of Milošević *et al.* (2020), the AERMOD model helps in gaining knowledge of the impact on air and humans due to different pollutants such as carbon dioxide, lead, sulphur dioxide, and many others. Further, these models are useful in stating the dispersion of air pollutants due to different turbulence.

Theme 2: Usefulness of MIKE 21 and WASP model in highlighting water quality

Water quality depends on the presence of pollutants in water, the more the presence of pollutants increases the more the quality drops. Mike 21 is one of the leading software that helps in modelling water quality. According to Talukdar, Kumar & Kulkarni (2023), oil is considered a pollutant for water and the ecological modules in MIKE 21 help to monitor the oil spill movement and transformation. Therefore, it appears that this model helps to monitor the presence of pollutants in water. Besides this model, another model, the Water Quality Analysis Simulation Program (WASP) is used to check the presence of pollutants in water.

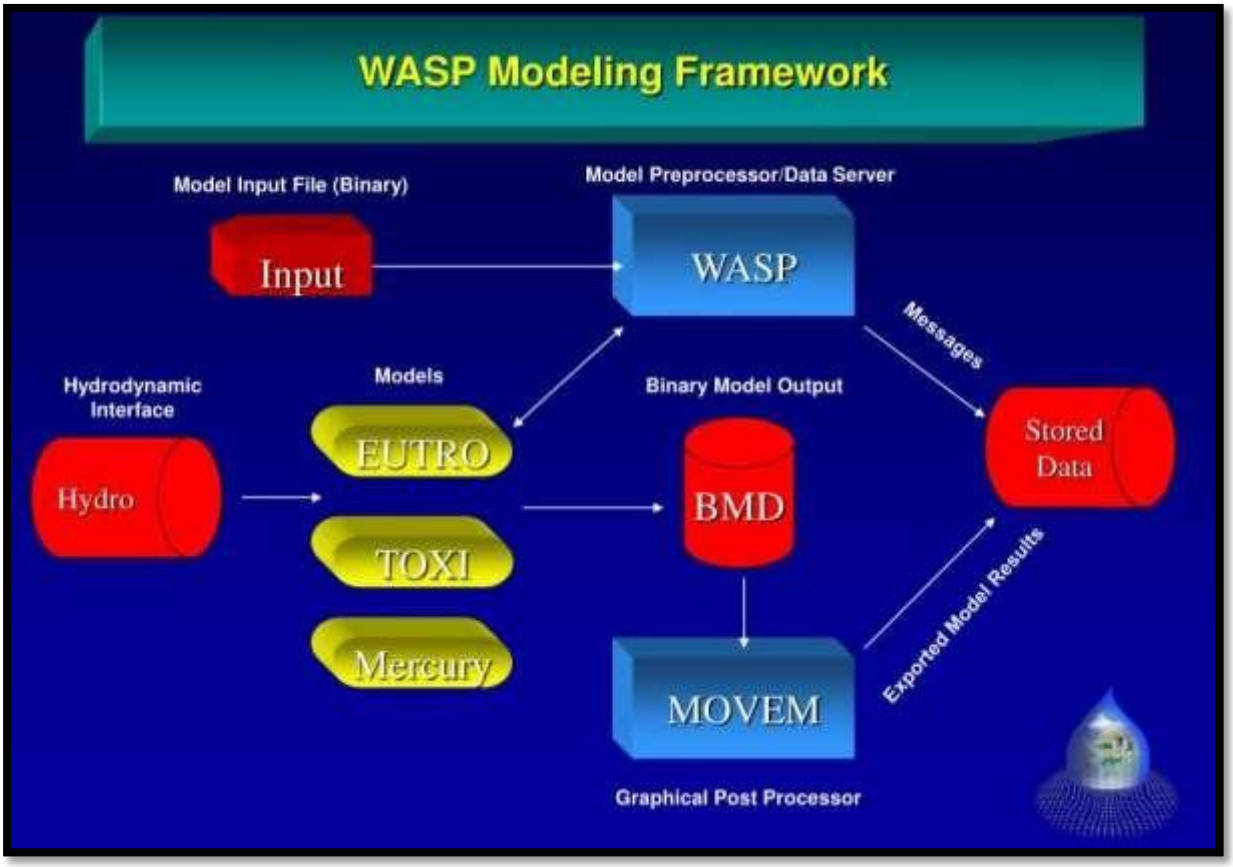

Figure 6: WASP Model

(Source: Influenced by Fida *et al.* 2023)

It has been seen WASP helps in detecting a variety of pollutants present in water (Epa.gov, 2023). It has been seen that water is a neutral liquid with a PH range between 6.5 and 8.5. As per the comment of Fida *et al.* (2023), the presence of pollutants ruins the PH balance. According to the WASP model, by determining the PH level of water with the help of a PH sensor, whether the water is polluted or not can be decided. Besides this, COD

sensors, Chlorine sensors and many other sensors are used to detect and monitor pollutants in water bodies.

Theme 3: Effectiveness of Soil Quality Index in soil testing

The inorganic elements and radioactive elements which are found in soil and bring harm to humans are known as soil pollutants. Monitoring soil contamination includes assessing the presence of pollutants such as chemical elements, plastics, and many others in the soil. As per the statement of Wołejko *et al.* (2020), the mixture of pollutants in soil drops the overall soil quality. It has been seen that the Soil Quality Index (SQI) is used to assess the soil quality which tells how much pollutants are mixed in the soil. Hence, to identify pollutants in soil, one needs to use the SQI.

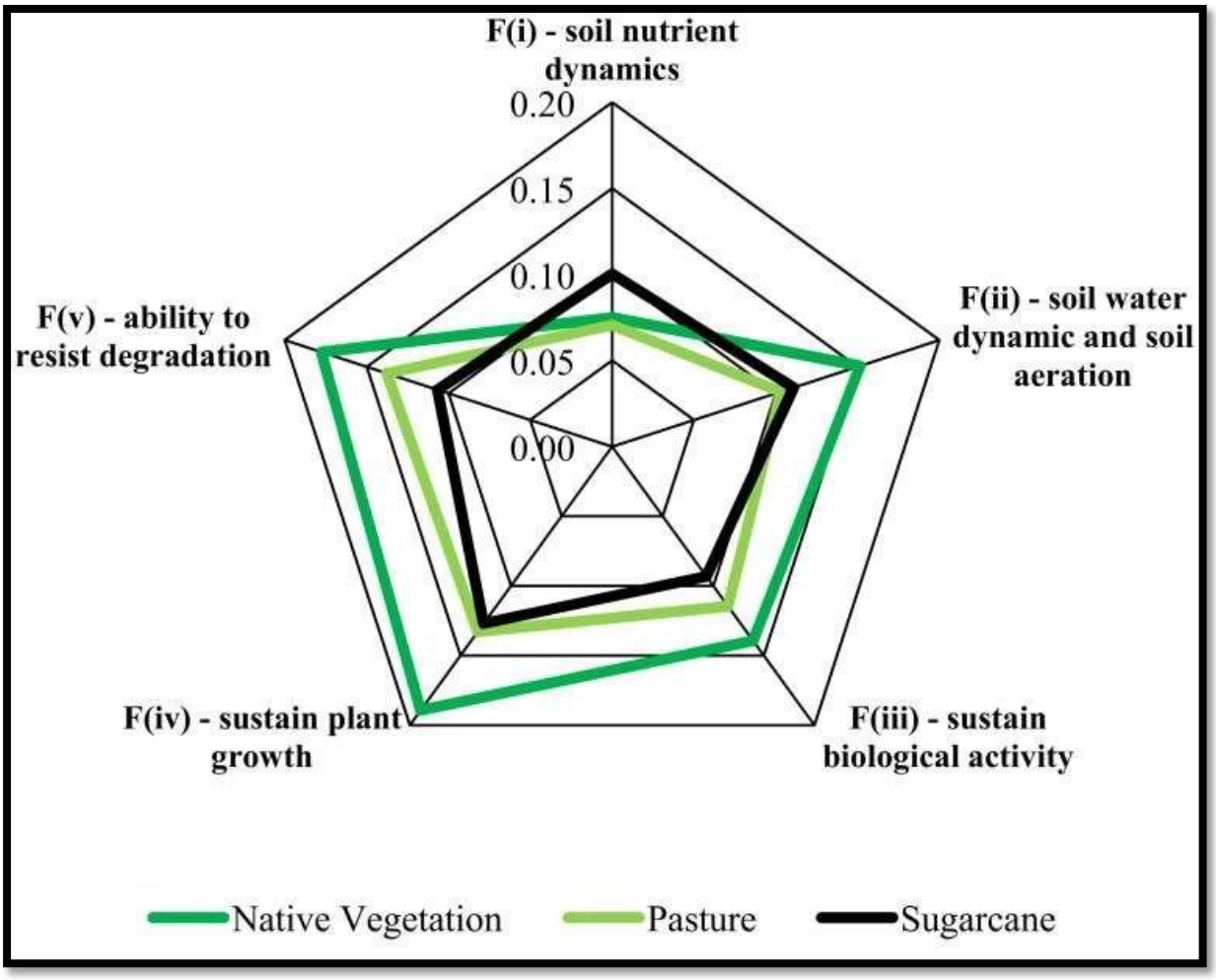

Figure 7: Soil Quality Index

(Source: Influenced by Yin *et al.* 2021)

According to SQI, the presence of different inorganic and radioactive components in soil can be determined and monitored through instruments like gas chromatograph, atomic absorption, and mass spectrometer. Measuring pollutants in soil means measuring soil pollution which is monitored by using Soil Probes (Yin *et al.* 2021). Further, by reviewing the specific area where dumped garbage is stored, plastic and other pollutants can be identified and monitored.

Theme 4: Different remedies to control pollutants in air, water, and soil

Reduction in the use of fossil fuel

Burning fossil fuels produces harmful gases and particles including carbon which is a key pollutant in the air and it is mostly used in cars across the world (Ogunkunle & Ahmed, 2021). Therefore, the first and foremost remedy to control the pollutants in the air is reducing the use of fossil fuels. Instead of fossil fuel, use renewable energy, biomass, and geothermal energy.

Reduction in the use of inorganic fertilisers

Inorganic fertilisers and pesticides contain harmful particles that disrupt the natural nutritional balance present in the soil (Rashid *et al.* 2023). During rain, it washes out and mixes with nearby water bodies which indicates that the use of these contains both soil and water pollutants. Hence, the remedy to control the pollutants in soil and water is reducing the use of inorganic fertilisers and promoting the use of organic ones.

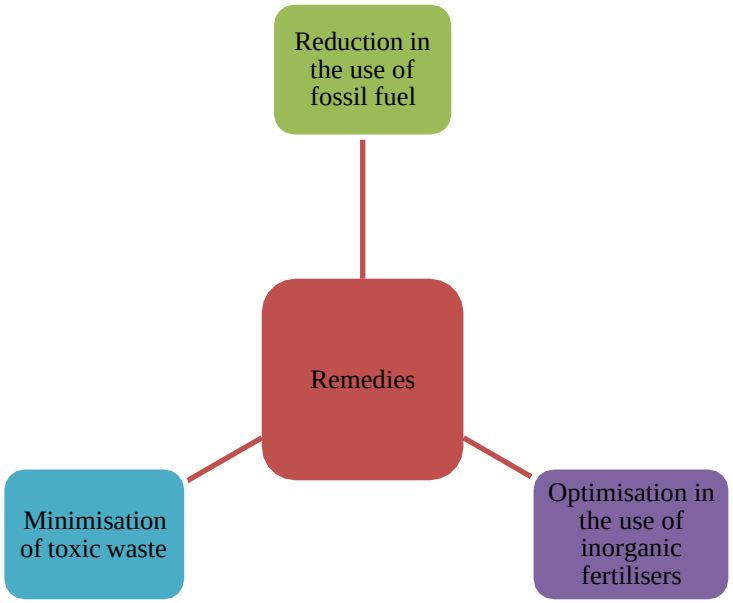

Figure 8: Different remedies

(Source: Influenced by Ogunkunle & Ahmed, 2021)

Optimisation of toxic waste

Releasing toxic waste in land and water causes soil and water pollution as it disrupts the PH balance and drives the growth of harmful bacteria (Pahalvi *et al.* 2021). Industrial waste includes toxic gases also which cause air pollution. Thus, the optimisation of releasing toxic waste into the environment is one of the effective remedies to control pollutants. It can be possible when industries use less-toxic alternatives in producing their products.

Discussion

From the above research, it can be stated that carbon dioxide, sulphur dioxide, carbon monoxide, and nitrogen oxides are harmful gases and lead, carbon, and sulphur are harmful particles that are key pollutants in the air. The primary reason for the production of these pollutants is the use of fossil fuels in daily life from mobility to the generation of electricity

(Dash *et al.* 2022). From the study, it can be stated that with the help of APM and AERMOD, pollutants in the air can be measured. However, from the study, it is found that the use of renewable energy, biomass, and geothermal energy instead of fossil fuel is an effective remedy to control air pollutants.

Pollutants present in the air cause acid rain and pollute water and soil. Elements present in industrial waste dumped in land and water are considered pollutants as they disrupt the quality of soil and water (Singh & Steinnes, 2020). Further, during the research, it has been found that the use of plastic products causes soil and water pollution as plastic is a critical pollutant since it is non-biodegradable. From the study, it can be stated that with the help of WASP and SQI pollutants in water and soil can be measured respectively. In order to optimise these pollutants, industries are required to optimise the release of toxic waste and humans are required to use organic fertilisers instead of inorganic fertilisers.

Conclusion

Thus, it can be concluded that in each aspect of the environment, different pollutants are present that harm humans. Therefore, monitoring these pollutants in three crucial environmental components, air, water, and soil, and controlling these pollutants becomes essential. From a small disease to a chronic disease can be the consequence of exposing the body to pollutants. The study sums up all major pollutants present in air, water, and soil along with the sources. From the study, it can be summarised that reducing the use of fossil fuels in daily lives, reducing the use of inorganic fertilisers and pesticides, and optimising the release of toxic waste can be effective remedies.

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