ISBN: 978-81-19149-42-1

5. Water Pollutants and Their Impacts on Human Health and Environment

Dr. Manish Kumar, Dr. Preetismita Borah

CSIR-Central Scientific Instruments Organization,
Chandigarh.

Abstract:

Inorganic pollutants are introduced into the environment through various uncontrolled anthropogenic activities, as well as natural additions from geogenic *activities. Water is a vital component of life, and therefore, the availability of safe and pure water is a fundamental right of all living beings. The presence of inorganic contaminants in water is due to the contact of water with rocks and soil, resulting in the natural mixing of chemical elements with minerals in water bodies.*

In recent years, the discharge of waste materials from industries, construction companies, and sewerage containing mineral acids (such as sulphuric acid, hydrochloric acid, and nitric acid), heavy metals, and trace elements (such as Cd, Hg, Pb, As, and Cr) has deteriorated the quality of water resources. These pollutants have a negative impact on aquatic flora and fauna, disrupting the ecological system and causing health problems in humans, such as liver and kidney damage and an increased risk of cancer. This chapter focuses on the range of priority and inorganic pollutants present in various water bodies.

Keywords:

Water pollutant, pollutant source, inorganic pollutant, health effect.

5.1 Introduction:

Inorganic pollutants are substances without carbon compounds. Rachel Carson (1962) illustrated the “emergence” of perception for Inorganic pollutants in her book titled “Silent Spring” [1].

These pollutants can arise naturally or through human activities such as manufacturing or the use of chemicals and materials. They have been extensively studied in various environmental systems, as they can disrupt the metabolism of both animals and humans.

While inorganic pollutants have been present in water for millennia, their potential to harm the environment, human health, and biological systems was not well understood until recently.

It is evident that polluted or toxic water can pose a significant threat to both human and animal populations that rely on it for survival.

Therefore, it is imperative to identify and remediate these toxic pollutants and minimize their harmful effects on our health and environment. Regulatory measures may be necessary to control the damage [2].

5.2 Water Pollutants:

Water pollution is a significant environmental issue that has been increasingly prevalent in modern times. It is widely acknowledged that the earth's surface is comprised of approximately 78% water.

As human beings continue to expand their industrial activities to meet their growing needs, chemical factories have been established on a large scale.

Unfortunately, the hazardous waste generated by these industries is often disposed of in the ocean, rivers, and even the atmosphere. This residue can exist in nature in either organic or inorganic form.

a. Organic Pollutants:

Organic pollutants have a biological origin. Herbicides and insecticides are examples of organic pollutants that are commonly utilized in agricultural and horticultural practices.

Additionally, food processing can generate harmful pathogens that are subject to scrutiny by food laboratories [3].

Similarly, harmful bacteria can be present in the cattle industry and can infiltrate water sources in various forms.

Furthermore, the decomposition of unused and unburned trees and plants can produce bacteria in bodies of water such as oceans, lakes, and ponds, leading to water pollution.

b. Inorganic Pollutants:

Inorganic pollutants generated by human activities, such as those emanating from factories and building constructions, have been identified as a significant cause of water channel degradation, including rivers and oceans.

Additionally, the discharge of chemical waste from cosmetic industries, detergents, chlorinated solvents, hydrocarbons, and other compounds from research laboratories contribute to the pollution of water bodies.

Common inorganic pollutants include heavy metals, chemical excess, silt from construction sites, and agricultural fertilizers [4].

Inorganic water pollutants are artificial substances or man-made chemicals, including pesticides, personal and household care products, pharmaceuticals, cosmetics, and other widely utilized compounds that reflect current lifestyles [5].

5.3 Sources: Eugenic and Anthropogenic:

Inorganic pollutants, acids, and micro-organisms are generated by waste and wastewater resulting from industrial, agricultural, or municipal activities.

The production of acidic pollutants typically arises from the decomposition of organic matter [6] and the discharge of pharmaceutical residues from hospitals and medical facilities into the natural environment.

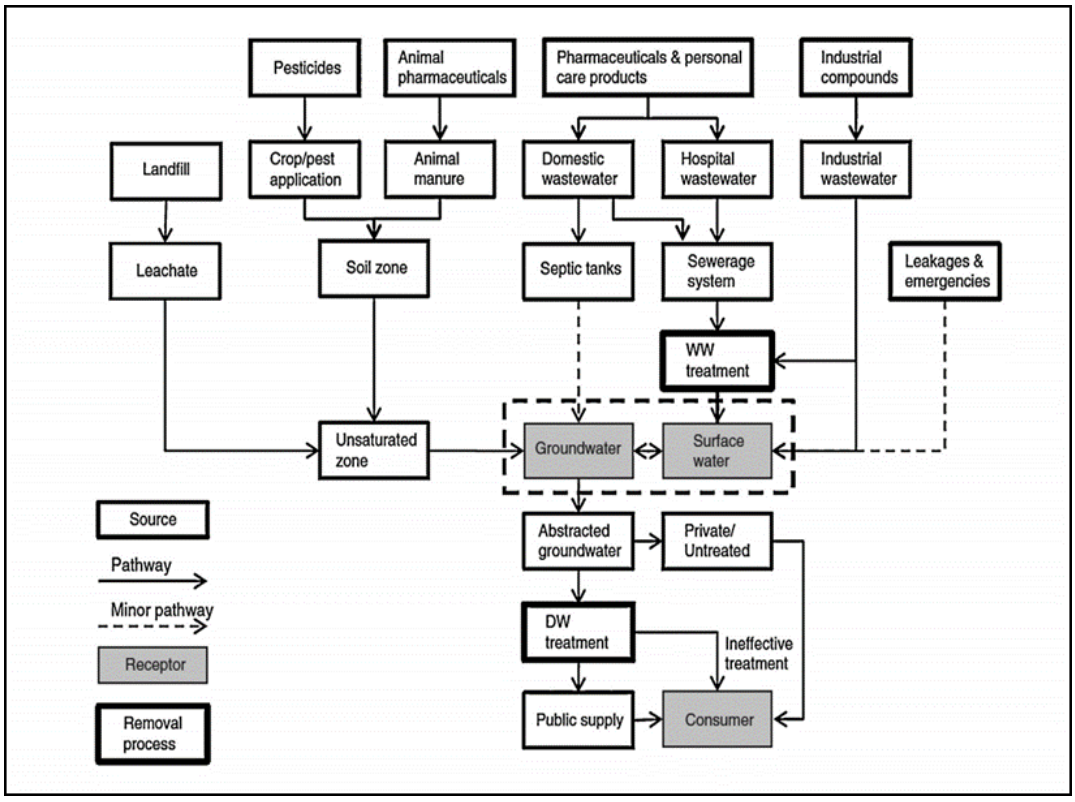

Figure 5.1: Schematic pathway of some inorganic pollutants from sources to receptors [7].

Contaminations may arise from either geogenic or anthropogenic sources. Groundwater is a composite of water composition that infiltrates the subsurface and kinetically controlled reactions with the aquifer matrix over an extended period, leading to an increase in ion concentrations in the groundwater [8].

Anthropogenic impacts, such as the use of nitrate as fertilizer and industrial waste, can modify groundwater in various ways. Geogenic groundwater pollution refers to groundwater that contains all-natural substances in varying concentrations with harmful health effects. Geogenic contaminations, such as fluoride and arsenic, have a significant impact on groundwater, making it challenging to provide pure mineral water in contaminated areas [9]. Additionally, salinity, iron, manganese, uranium, radon, and chromium are also present in higher amounts in groundwater, which may have a geogenic origin.

The second category of sources of groundwater contamination is anthropogenic in nature, resulting in a decline in the quality of groundwater due to the presence of pollutants and acidic contaminants. This type of contamination arises as a result of human activities, including municipal, industrial, and agricultural practices. Anthropogenic contamination sources can be classified into two categories: direct and indirect impacts. Direct anthropogenic contamination refers to substances that directly affect groundwater quality, such as nitrate, phosphate, salinity, heavy metals, sewage, improper waste disposal, and oil spills. These contaminants indirectly affect the water quality.

Additionally, certain anthropogenic activities can alter the geochemical conditions of groundwater, such as dewatering in lignite mines or acid mine drainage [10]. Arsenic is known to increase in concentration under reducing conditions due to groundwater abstraction for water supply, irrigation, geothermal power plants, or mining activities [11].

Agricultural activities are a primary contributor to anthropogenic pollution. When pesticides, fertilizers, herbicides, and animal waste are applied in excessive amounts, they can lead to the development of anthropogenic contaminants in both the ground and groundwater. Industrial activities are the second most significant source of anthropogenic pollution. Improper disposal of industrial residues can lead to groundwater pollution.

In addition to agricultural and industrial activities, transportation, manufacturing, processing, and construction waste are also sources of groundwater contamination. In the past, irregular disposal of sewage waste has been found to be harmful to groundwater. Cesspools, dry wells, and septic tanks have been used to dispose of wastewater, all of which contribute to the contamination of underground water sources. Storage tanks containing fuels, oils, acids, solvents, and chemicals may also leak due to corrosion, defects, lack of installation, or mechanical failure in the supply pipes and fittings, leading to groundwater contamination. Mining of fuel and non-fuel minerals also contributes to groundwater contamination. Wastewater from residential areas is another source of various contaminants, including bacteria, viruses, nitrates, and organic compounds. In recent times, injection wells have been used for household wastewater disposal, but septic systems, cesspools, drainage wells for storm water runoff, and groundwater recharge wells have also been found to contribute to poor quality groundwater.

5.4 Health Impacts:

Polluted water has deleterious effects on the environment, as well as on humans and animals. Statistical data confirms that approximately one billion individuals are directly impacted by toxic polluted water annually, resulting in illness and various health complications. In developing countries, individuals belonging to the lower socioeconomic class often reside in close proximity to industrial areas, thereby increasing their exposure to contaminated groundwater and subsequent health risks. Consequently, this demographic is at a higher risk proportionally than others. Furthermore, heavy metals, dyes, and other organic pollutants are known to be carcinogenic, while hormones, pharmaceuticals, cosmetics, and personal care product wastes are classified as endocrine disruptive chemicals [12].

Humans consume toxic heavy metals through their food and water, which contain these metals [13]. The effects of toxic heavy metals on various human organs include mild eye, nose, and skin irritations, headaches, stomach aches, diarrhea, hematemesis, vomiting, cirrhosis, necrosis, low blood pressure, hypertension, and gastrointestinal distress [14].

It is noteworthy that certain heavy metals, such as cobalt, copper, iron, manganese, vanadium, and zinc, are considered essential elements that are required in small quantities by various biochemical systems within the body. Conversely, other heavy metals, including lead, cadmium, arsenic, and mercury, are deemed foreign to the body due to their detrimental health effects. The consumption of arsenic-contaminated water has been linked to the development of lung, liver, and bladder cancer, while cadmium-contaminated water may result in kidney damage, lung impairment, and bone fragility.

The consumption of lead has been found to have numerous negative effects on the human body, including damage to the brain and kidneys. Even small amounts of lead can disrupt the learning process, cause memory loss, affect attention and response functions, and lead to aggressive behavior in children [15, 16].

Pregnant women who are exposed to high levels of lead may experience miscarriage, while men may experience reduced sperm production. Mercury, which is widely used for various purposes, is a global pollutant that has broad side effects on health.

It exists in two forms, organic and inorganic. Organic type mercury like methyl mercury (MeHg) and dimethyl mercury (DMeHg) is more toxic comparatively to inorganic type mercury [17].

Mercury enters the body through the blood and exits through urinal excretion and scat. It is important to note that mercury can remain in the urine for up to 60 days, indicating its renal maladaptive characteristic. Exposure to heavy metals can lead to several mentally hazardous conditions and instant metabolic system transformations [18]. Consuming heavy metals in extreme concentrations can also disrupt hunger for food, leading to weight loss and decreased reproduction in adults and larvae growth [19].

Organic pollutants of varying degrees of toxicity have been detected in groundwater. These pollutants pose a significant threat to aquatic organisms, plants, and humans, as they are commonly found in waste products such as dyes, pharmaceuticals, personal care items, and petroleum pollutants. Dyes, for instance, are widely used in liquid form for a variety of applications, including textile and leather manufacturing, tanning, food production, and paper production, among others. However, dyes can have a detrimental impact on aquatic life by obstructing sunlight and reducing dissolved oxygen levels, leading to the death of photosynthetic organisms and other aquatic species [20]. Humans can also be affected to dye toxicity through the consumption of vegetables and fish that have bio-accumulated dyes, as well as through the use of colored paper towels for hand drying and food preparation [21]. To mitigate the risks associated with dye pollution, it is crucial to remove dyes from wastewater, as they have been linked to carcinogenic and mutagenic effects.

Pharmaceuticals have been utilized in hospitals and medical facilities at various chemical concentrations ranging from parts per billion (ppb) to parts per million (ppm). The disposal of these chemical samples has resulted in water contamination, which has had adverse effects on human health and other forms of life [22].

Studies have shown that pharmaceuticals have been linked to acute and chronic toxicity in aquatic organisms, leading to an increased risk of cancer and other health issues [23, 24]. Furthermore, the presence of pharmaceuticals in water has been found to decrease the number of eggs in females and sperm count in males [25, 26].

5.5 Environmental Impacts:

The bio-degradation process utilized for organic materials found in sewage waste requires a significant amount of oxygen. This oxygen depletion can have a detrimental effect on fish and aquatic animals, leading to their demise. Additionally, the excessive presence of nutrients can result in the rapid growth of algae in water sources, ultimately leading to the aging of these sources.

The discharge of industrial water waste, such as mercury and DDT, can have a bio magnification effect on the aquatic food chain. When birds consume DDT in high concentrations as a food supplement, it can damage their calcium metabolism, resulting in thin eggshells and premature breaking.

This negative impact can reduce the bird population and disrupt the environmental balance. The discharge of wastewater from thermal plants can decrease the number of microorganisms present due to high temperatures, which can enhance plant growth and fish populations in colder regions.

However, this can also lead to the destruction of indigenous flora and fauna. Pesticides present in acidic wastewater can exist in aquatic organisms and transform into the food chain, causing environmental diversity. The discharge of waste water in various forms can lead to the toxicity of ocean, pond, or lake water, which can harm the survival of shellfish and coral.

5.6 Conclusions:

It is widely acknowledged that water is an essential requirement for the survival, sustainability, and preservation of human beings and other living organisms. However, in the current scenario, pure water sources are being contaminated by various human activities and groundwater chemical substances, which have a significant impact on the ecosystem, climate transformation, and human health.

To prevent this, wastewater is treated before being discharged by industries using various methods. However, untreated water is still being supplied.

Therefore, it is imperative that the government and environmental protection agencies implement policies aimed at preventing such contamination to safeguard the environment and living organisms.

These policies should be based on factual evidence and performance and should be focused on achieving specific objectives and goals. Such measures will undoubtedly be a positive step towards enhancing water quality and eliminating water pollutants.

5.6 References:

1. R. Carson, Silent Spring - 40th Anniversary Edition. Boston, Mariner (2002).
2. S. Sauve, M. Desrosiers, a review of what is an emergent contaminant? Chem. Cent. J. 8 (2014) 15.
3. T.F. Landers, B. Cohen, T.E. Wittum, E.L. Larson, A review of antibiotic use in Food animals: perspective, policy, and potential. Public Health Rep. 127(1) (2012) 4–22.
4. E. Lombi, R.E. Hamon, Encyclopedia of soils in the environment. (2005).
5. N.S. Thomaidis, A.G. Asimakopoulos, A.A. Bletsou, Inorganic contaminants: a tutorial mini-review. Global NEST J. 14 (2012) 72–79.
6. S.R. Sørensen, M.S. Holtze, A. Simonsen, J. Aamand, Degradation and mineralization of nanomolar concentrations of the herbicide dichlobenil and its persistent metabolite 2,6-dichlorobenzamide by Aminobacter spp. isolated from Dichlobenil-treated soils. App. Environ. Microbio. 73 (2007) 399–406.
7. M. Stuart, D. Lapworth, E. Crane, A. Hart, Review of risk from potential Inorganic contaminants in UK groundwaters. Sci. Total Environ. 446 (2012) 1–21.
8. C.A.J. Appelo, D. Postma, Geochemistry, groundwater and pollution, second ed. Balkema, Rotterdam 241–309 (2005).
9. Eawag, Geogenic Contamination Handbook – addressing Arsenic and Fluoride in drinking water. C.A. Johnson, A. Bertzler (Eds.), Swiss Federal Institute of Aquatic Sci. Tech. (Eawag), Dubendorf, Switzerland (2015).
10. C. Kohfahl, the influence of water table oscillations on pyrite weathering and acidification in open pit lignite mines; column studies and modelling of hydro geochemical and hydraulic processes in the LOHSA storage system, Germany; Ph.D. Thesis. Berlin, 111 pp; ISBN 3-89825-774-6 (2004).

11. Guidelines for Drinking-water Quality, third edition, World Health Organization, Geneva, Switzerland (1997).
12. A.O. Adeogun, O.R. Ibor, S.D. Adeduntan, A. Arukwe, Intersex and alterations in the reproductive development of cichlid, Tilapia Guineensis, from a municipal domestic water supply lake (Eleyele) in south western Nigeria. Sci. Tot. Enviro. 541 (2016) 372-382.
13. C. Popa, M. Petrus, Heavy metals impact at plants using photoacoustic spectroscopy technology with tunable CO2 laser in the quantification of gaseous molecules. Microchem. J. 134 (2017) 390-399.
14. A.O. Dada, F.A. Adekola, E.O. Odebunmi, Kinetics and equilibrium models for sorption of cu (II) onto a novel manganese nano-adsorbent. J. Disper. Sci. Tech. 37(1) (2015) 119-133.
15. M. Verma, J.S. Schneider, Strain specifc effects of low level lead exposure on associative learning and memory in rats. Neurotox. 62 (2017) 186-191.
16. B. Sun, X. Zhang, Y. Yin, H. Sun, H. Ge, W. Li, Effects of sulforaphane and vitamin E on cognitive disorder and oxidative damage in lead-exposed mice hippocampus at lactation. J. Trace Elem. Med. Bio. 44 (2017) 88-92.
17. Z. Liu, L. Wang, J. Xu, S. Ding, X. Feng, H. Xiao, Effects of different concentrations of mercury on accumulation of mercury by five plant species. Ecology. Eng. 106 (2017) 273-278.
18. P. Li, B. Du, M.C. Chan, X. Feng, Human inorganic mercury exposure, renal effects and possible pathways in Wanshan mercury mining area, China. Environ. Res.140 (2015) 198-204.
19. C. Zhang, K. Yua, F. Li, J. Xiang, Acute toxic effects of zinc and mercury on survival, standard metabolism, and metal accumulation in juvenile ridge tail white prawn, Exopalaemon Carinicauda. Eco toxic. Environ. Saf. 145 (2017) 549-556.
20. C. Jung, A. Son, N. Her, K. Zoh, J. Cho, Y. Yoon, Removal of endocrine disrupting compounds, pharmaceuticals, and personal care products in water using carbon nanotubes: A review. J. Indus. Eng. Chem. 27 (2015) 1-11.
21. M. Oplatowska, R.F. Donnelly, R.J. Majithiya, D.G. Kennedy, C.T. Elliot, the potential for human exposure, direct and indirect, to the suspected carcinogenic triphenyl

methane dye brilliant green from green paper towels. Food and Chemical Toxicology. 49 (2011) 1870-1876.

22. E. Archer, B. Petrie, B.K. Hordern, G.M. Wolfaardt, The fate of pharmaceuticals and personal care products (PPCPs), endocrine disrupting contaminants (EDCs), metabolites and illicit drugs in a WWTW and environmental waters. Chemosphere 174 (2017) 437-446.
23. S. Kar, K. Roy, First report on interspecies quantitative correlation of Eco toxicity of pharmaceuticals. Chemosphere 81 (2010) 738-747.
24. G.V. Aguirre-Martínez, C. Okello, M.J. Salamanca, C. Garrido, T.A. Del Valls, M.L. Martín-Díaz, Is the step-wise tiered approach for ERA of pharmaceuticals useful for the assessment of cancer therapeutic drugs present in marine environment? Environ. Res. 144 (2016) 43-59.
25. I. Akanyeti, A. Kraft, M. Ferrari, Hybrid polystyrene nanoparticle-ultrafiltration system for hormone removal from water. J. Water Process Eng. 17 (2017) 102-109.
26. C.K. Ng, C.D. Bope, A. Nalaparaju, Y. Cheng, L. Lu, W.R. Bin Cao, concentrating synthetic estrogen 17a-ethinylestradiol using microporous polyether sulfone hollow fiber membranes: Experimental exploration and molecular simulation. Chem. Eng. J. 314 (2017) 80-87.