# Newsletter

Volume 2, Issue 3, December 2019

# Voice of Environment

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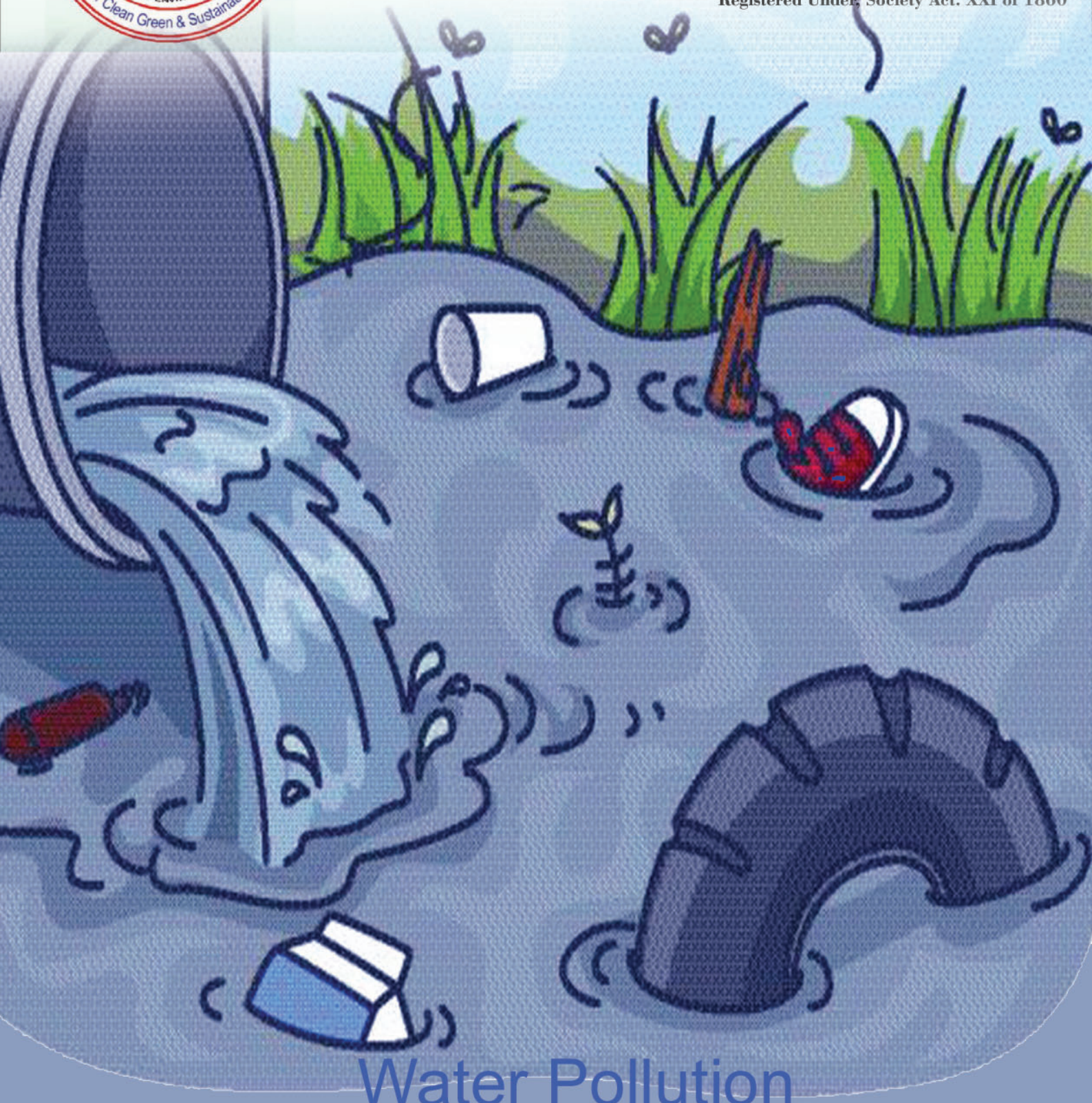

## Water Pollution

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# *Voice of Environment Newsletter*

***Volume: 2, Issue: 3***

***December, 2019***



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## From the Editorial Desk:

Water is one of the most critical resources globally that is being compromised on a daily basis due to consumption and overexploitation. Unplanned urbanization, unsustainable industrialization trends, unscientific town planning and deforestation has led to stress on water resources leading to groundwater depletion, run-off and water losses, water pollution and contamination. Countries such as India and Bangladesh also face the problem of heavy metal Arsenic in water. This has caused major health ailments and potable water toxicity among large populations in densely populated gangetic West Bengal. The most important water contaminants created by human activities are microbial pathogens, nutrients, oxygen-consuming materials, heavy metals and persistent organic matter, as well as suspended sediments, nutrients, pesticides and oxygen-consuming substances, much of it from non-point sources. Heat, which raises the temperature of the receiving water, can also be a pollutant. Pollutants are typically the cause of major water quality degradation around the world as per UNESCO WWAP (World Water Assessment Programme). Globally, the most prevalent water quality problem is eutrophication, a result of high-nutrient loads (mainly phosphorus and nitrogen), which substantially impairs beneficial uses of water. It is high time we discuss and act on this burning issue! Water is crucial for advancing human rights, reducing poverty and inequality, and enabling peace, justice and sustainability. SDG 6 on clean water and sanitation therefore provides a unique opportunity to accelerate progress on the 2030 Agenda. Optimal utilization of water as a resource and strategic allocation to end poverty is the need of the hour. We must all work together to realize this goal.

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## MESSAGE

**I take this opportunity of forwarding a message on Water Pollution with special reference to 'Groundwater arsenic contamination and its entry in food chain, for Voice of Environment Newsletter. Approximately, seventy incidents of groundwater arsenic contamination and illnesses of people have been reported all over the world. Among all of those, five major calamities happened in Asia. Those affected areas are, West Bengal (India); Bangladesh; Inner Mongolia, Xin Xiang Province (China) and Taiwan. Nowadays, it's a huge challenge to fight against this devastating calamity across the world because of arsenic which enters in food chain mainly through drinking water (groundwater) and foodstuff cultivated using contaminated groundwater.**

**Natural groundwater arsenic contamination and the resulting toxic effect have become one of the greatest challenges to human health in modern times, with large parts of the Ganga-Meghna-Brahmaputra plain of India with an area 569,749 km$^2$ and population over 500 million exposed to such a risk. The calamity in these places, particularly in Bengal delta, with over 100 million people living in zones has assumed gargantuan proportions as arsenic levels in drinking water has overshot far above the guidelines set by World Health Organization (WHO) at 10 µg/L. Furthermore, what is worrisome is that arsenic-contaminated groundwater is increasingly being used to irrigate the fields. Thus, arsenic has begun to seep into crops and food chain which could trigger a large scale environmental tragedy, fatally affecting future generations. Accumulation of arsenic in rice, the staple crop is a further environmental concern and topics of research interest.**

**27$^{th}$ November, 2019**

**Tarit Roychowdhury**

*Invited Article*

# Groundwater arsenic contamination with special reference to its accumulation in rice grain during cultivation and domestic scale post harvesting

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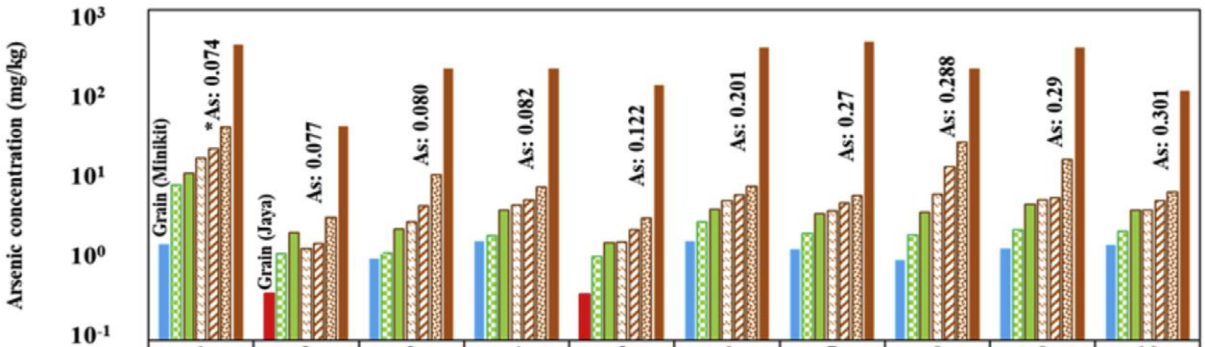
Natural groundwater arsenic (As) contamination and the resulting toxic effect have become one of the greatest challenges to human health in modern times, with large parts of the Ganga-Meghna-Brahmaputra plain of India with an area 569,749 $km^2$ and population over 500 million exposed to such a risk [1]. The calamity in these places, particularly in Bengal delta, with over 100 million people living in zones has assumed gargantuan proportions as arsenic levels in drinking water has overshot far above the guidelines set by World Health Organization (WHO) at 10 µg/L. Furthermore, what is worrisome is that arsenic-contaminated groundwater is increasingly being used to irrigate the fields. Thus, arsenic has begun to seep into crops and food chain which could trigger a large-scale environmental tragedy, fatally affecting future generations [1, 2]. Arsenic is a naturally occurring element and arsenic levels in foods generally reflect its natural accumulation from the environment. Irrigation of agricultural fields with arsenic-contaminated groundwater has led to arsenic build-up in soil, with subsequent elevation of arsenic in crops grown on these soils. High levels of arsenic were reported in the rice grain obtained from arsenic-affected districts of West Bengal. Besides domestic use, groundwater is widely used for irrigation in Bengal delta during the dry season (December–April), particularly for growing of the dry season rice called boro (which requires about 1 m of irrigation water each year). To meet the food demands of the increasing population in the Bengal delta, the growing season has been expanded from one to four or five crops per year. Rainwater alone can no longer meet the water demand of such intensive agriculture, since only limited rainfall occurs during the dry season. Therefore, agriculture has shifted to using groundwater to supplement the rainwater supplies. Approximately, tens of thousands of shallow large-diameter tube wells are used for agricultural irrigation in West Bengal.

A total of 925,152 shallow and 24,718 deep tube wells were used for irrigation during the dry season in Bangladesh. Groundwater irrigation covered about 75% of the total irrigated area. Boro cultivation and irrigation have altogether increased since 1970, and from the 1980s to the present, the area under groundwater irrigation has increased by almost an order of magnitude. During the dry season of 2003, about 87% of the total irrigated area of about 4 million hectares (about 28% of the total area in Bangladesh) was under boro cultivation and boro accounted for about 49% of the total rice production. Many millions of cubic meters of underground water are used for agricultural irrigation.

Much of this groundwater is contaminated with arsenic, which is deposited in the soil in contact with the irrigation water throughout the year. Except in the rainy season (June–October), the agricultural land soils have been exposed to irrigated groundwater round the year. Sometimes, the farmers used to run the shallow tube wells in the rainy season due to insufficient rain. As a result, groundwater exploitation goes on unchecked. The status of aquifer exploitation was as high as 79.4% from a single district, North 24-Parganas in West Bengal. About 6.4 tons of arsenic was withdrawing in a year from the shallow large-diameter tube wells in use for agricultural irrigation in Deganga block, North 24-Parganas district.

However, people evading arsenic exposure through drinking water are unknowingly exposed to a greater risk of arsenic contamination through food products grown with arsenic containing groundwater. Paddy plants grown in such areas already have a higher arsenic content in most of the cases [3]. This is because the ground water used for irrigating paddy fields generally contains a large amount of arsenic. Arsenic accumulation in paddy plants at different phases of pre-monsoon cultivation has been further studied. Arsenic is translocated from root to aerial parts in descending order (**Fig. 1**). Leaf, stem, root, root soil and surface soil showed a similar trend in their change of arsenic concentration throughout the cultivation period. Arsenic concentration was the highest during the vegetative phase; sharply declined during the reproductive phase and moderately increased during the ripening phase (**Fig. 2**). The young root tissues in the vegetative (primary) phase could uptake arsenic at a much faster rate than the older tissues in later phases. With the growth of the plant, higher concentrations of iron in the root soil during the reproductive phase confirmed the formation of iron plaques on the surface of the root, which sequestered arsenic and prevented its uptake by plants [3].

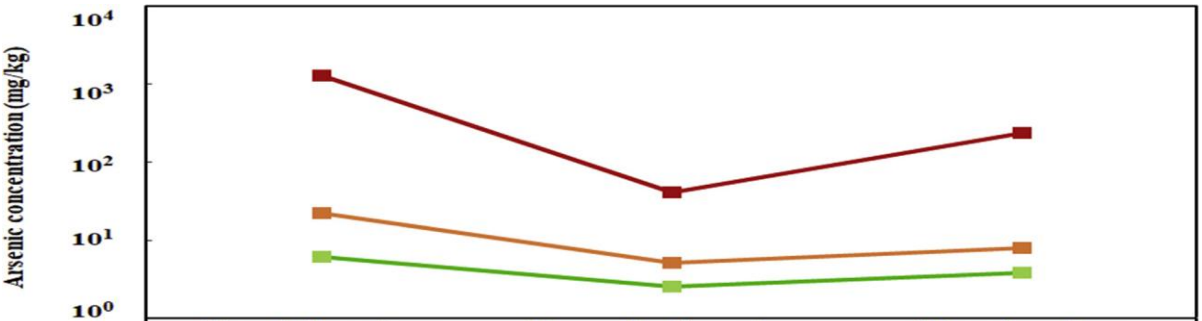
Finally, co-precipitation of arsenic with iron released from crystallized iron plaques results in loosening of the iron plaques from root surface (**Fig. 3**). Thus, soil arsenic concentration increases in the final phase of cultivation which in turn contributes to increased concentration in plant parts.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Grain | 1.46 | 0.37 | 0.97 | 1.56 | 0.36 | 1.56 | 1.27 | 0.93 | 1.28 | 1.43 |
| Pedicle | 7.59 | 1.12 | 1.13 | 1.85 | 1.03 | 2.72 | 1.95 | 1.88 | 2.18 | 2.10 |
| Leaf | 10.5 | 1.99 | 2.19 | 3.75 | 1.50 | 3.84 | 3.38 | 3.50 | 4.37 | 3.74 |
| Stem (8-12) | 16.1 | 1.29 | 2.70 | 4.32 | 1.53 | 4.83 | 3.70 | 5.83 | 4.98 | 3.72 |
| Stem (4-8) | 20.6 | 1.49 | 4.20 | 4.98 | 2.19 | 5.76 | 4.58 | 12.53 | 5.32 | 4.82 |
| Stem (0-4) | 37.8 | 3.04 | 10.1 | 7.13 | 2.97 | 7.20 | 5.57 | 25.0 | 15.4 | 6.22 |
| Root | 380 | 38.6 | 193 | 193 | 122 | 351 | 406 | 195 | 349 | 103 |

*** Arsenic concentration of ground water in mg/l**

**Fig. 1. As concentrations (mg/kg) in various parts of paddy plant at final phase before harvesting [3]**




| | Vegetative stage | Reproductive stage | Ripening stage |
|---|---|---|---|
| Leaf | 6.12 | 2.54 | 3.87 |
| Stem | 21.85 | 5.08 | 7.85 |
| Root | 1278.9 | 40.51 | 233.23 |

**Fig 2. Trend of variation in arsenic concentrations (mg/kg) of leaf, root and stem at three phases of paddy cultivation [3]**

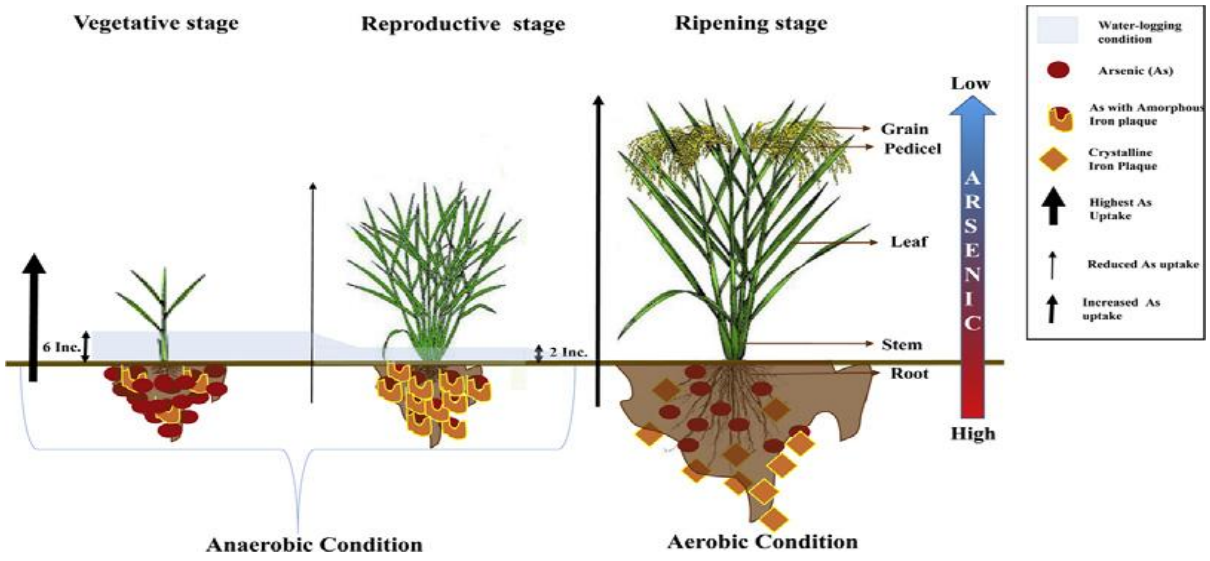



**Fig 3. Formation of iron plaque that sequesters arsenic in reproductive phase and recrystallization of iron plaque that makes arsenic available in ripening phase [3]**

Arsenic contaminated paddy is further subjected to a greater arsenic accumulation as a result of being processed in contaminated water, as a part of the regular parboiling procedure followed after the crop has been harvested and this showed higher accumulation of arsenic in parboiled rice grain compared to raw or sunned rice grain [4]. Investigation on the role of parboiling procedure of rice being cultivated and processed in arsenic prone areas suggested that parboiling of rice with arsenic contaminated groundwater contributes majorly in the increment of arsenic concentration in parboiled rice (**Fig. 4**) and its by-products. The study analyzed that rice by-products prepared from parboiled rice grains contained higher arsenic concentrations than those prepared from raw rice grain. Following such observations, parboiled rice of different strains showed much higher arsenic concentrations than that of raw rice strains. Analyses of arsenic concentrations of paddy whole grains at various stages of parboiling showed an overall increase in finally parboiled grain from that of initial raw grain, suggesting accumulation of arsenic from water during parboiling. A large part of the aforesaid population uses parboiled rice as their staple food. Arsenic accumulation in paddy due to use of contaminated groundwater during its harvesting and the subsequent impact on arsenic enrichment of the crop are further environmental challenges. Moreover, use of arsenic enriched water during cooking process in domestic scale enhances arsenic concentrations in cooked rice [2].

What is further worrisome is that the transportation of the arsenic-contaminated crops and vegetables grown using arsenic-contaminated groundwater and soil in arsenic-exposed areas to the uncontaminated sites and consequent dietary intakes leads to great threats for the population residing in non-endemic areas with respect to consumption of arsenic through drinking water [5].

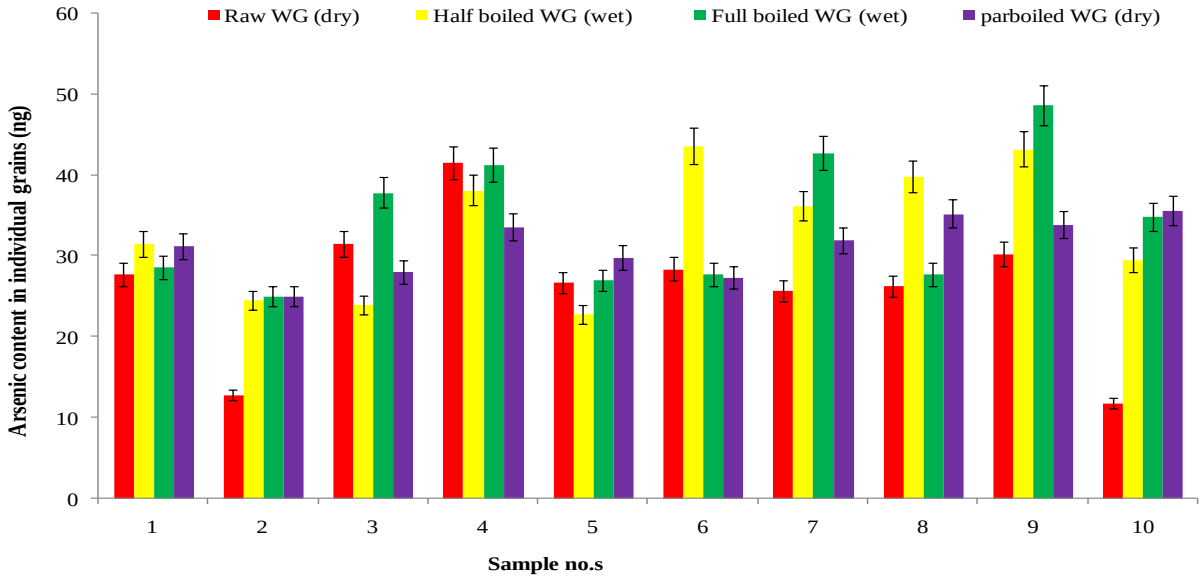



**Fig. 4. Histogram showing arsenic content of individual whole grain samples at various stages of parboiling [4]**

Due to its affinity for metal oxides/hydroxides in soil, the accumulation of arsenic in irrigated surface soils is expected and a number of studies have reported elevated concentrations of arsenic in agricultural field soils irrigated with arsenic-contaminated groundwater. The distribution of arsenic in plants, in general is in descending order from root to stem and leaf to edible parts. Approximately 3.1–13.1%, 0.54–4.08% and 0.36–3.45% of arsenic in root, stem and leaf, respectively was taken up from the soil in the studied agricultural lands from West Bengal. In general, arsenic availability to plants is highest in coarse-textured soils having little colloidal material and little ion exchange capacity, and lowest in fine-textured soils high in clay, organic material, iron, calcium and phosphate. To be absorbed by plants, arsenic compounds must be in a mobile form in the soil solution.

Detection of arsenic in rice, the staple crop, an element known to be carcinogenic to humans, has been the topic of high public interest.

Under anaerobic flooded conditions, arsenic in soil is converted readily to arsenite which is mobile, leading to arsenic in rice grain being around 10-fold higher than for other crops [6]. Other than drinking water, presence of elevated levels of inorganic arsenic, mainly arsenite and arsenate in food chain is a potential health risk for the human continuum and other animals in the Bengal delta [2]. Inorganic arsenic (mainly arsenite and arsenate) and DMA contribute approximately 90% and 10%, respectively of the total content of arsenic in crops and vegetables (**Fig. 5**). As rice is the staple food in rural Bengal, the daily dietary intake of the inhabitants is mainly controlled by rice grain and its by-products. Arsenic is translocated from root into the aerial organs in amounts decreasing from stem to leaf to edible parts. Accumulation of arsenic in soil and different paddy parts is maximum during water-logged condition. Parboiled rice grain shows a 42% higher value of arsenic than that of sunned (raw) rice grain during post harvesting procedure in domestic level. Arsenic accumulation in paddy plant/rice grain during harvesting and post harvesting in the domestic level have also been investigated. Other than cooked rice, various by-products of rice grain contribute a significant amount of arsenic which is important in environmental health perspectives to humans and other domestic animals. Attempts have been taken to reduce arsenic concentration in foodstuff during cultivation and food preparation. Different ratios of water (arsenic free) added to contaminated rice grain can further decrease the arsenic content in cooked rice.

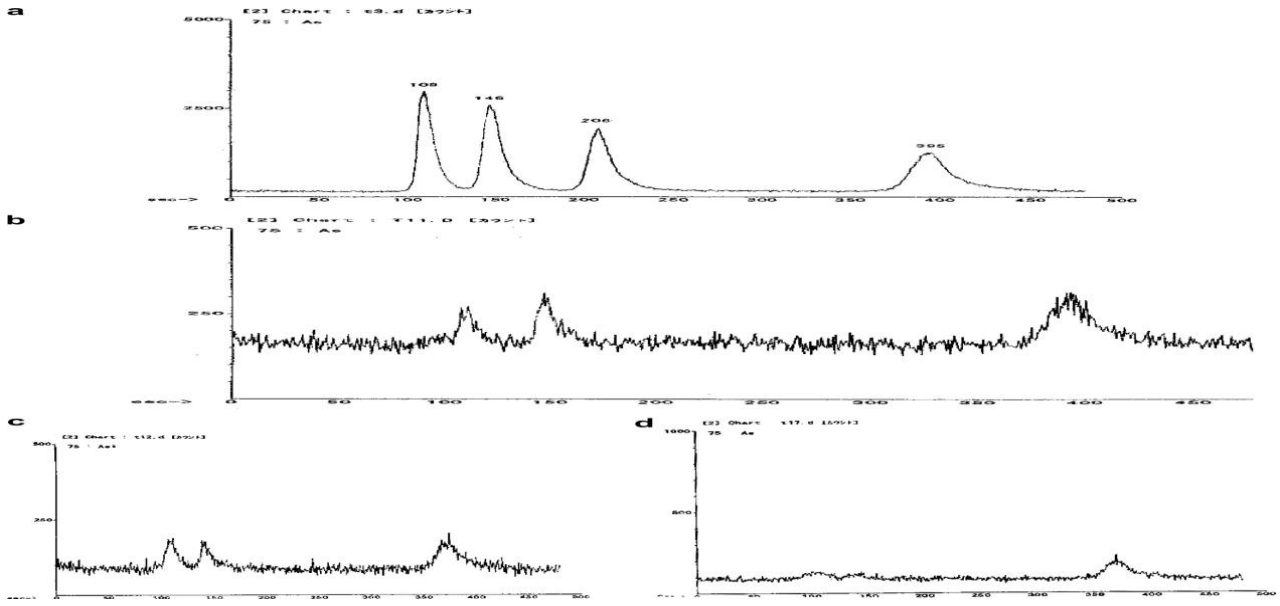



**Fig. 5. HPLC chromatogram of As (III), DMA, MMA and As (V) species in (a) standard 30 ppb solution; (b) rice grain 1; (c) rice grain 2; (d) vegetable leaf [2]**

The mobility and toxicity of arsenic in soil environment depend largely on its chemical species. In addition to abiotic factors (pH, redox potential of soils, adsorption of metallic oxides and organic matter, etc.), it has been suggested that microorganisms play a major role in modulating arsenic speciation (reduction, oxidation and methylation) and its mobility. The rates and directions of arsenic biotransformation in soil-plant systems largely depend on the microbial communities, both functional diversity and the expression of functional genes under various environmental conditions. By using molecular tools, it is now possible to unravel the microbial processes in the soil that governs the fate and toxicity of arsenic.

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# Anthropogenic activities causing River Pollution and its Impact on the Environment

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## 1. Introduction

Rivers are naturally flowing, usually, the freshwater body which flows towards an ocean, sea, lake, or another river. Most of the river begins their life as a tiny stream running down mountain slopes which are fed by melting snow and ice or by rainwater running off the land. They play an essential role in the hydrological cycle as it collects water from precipitation and returns it the oceans.

## 2. Significance of rivers

- Rivers drain nearly 75% of the earth's land surface and carry water and nutrients all around the earth.
- Evolution suggests that life originated in water. History shows that almost all the civilizations appeared on the banks of the river because all living organisms can get their essential needs from the waterbody. Human can get direct food in the form of fishes, crabs, prawn, etc., from river and also it makes plains fertile, and provide water for irrigation.
- **Energy and Transportation**: The force of flowing water is used to generate hydroelectricity. The river serves as the medium for transport as many ships, boats, tourist cruises make their way through it. In Scandinavia regions and Canada, lumberjacks float felled trees in the river to the downstream lumber camps for further processing.
- **Industries & Infrastructure**: Almost all industries require water for their operation, so most of the industries are situated near river banks.

## 3. River Pollution

When pollutants (such as untreated sewage, industrial discharge, etc.) directly or indirectly are discharged into rivers and the natural condition of the river become changed with contaminated substances, that is termed as river pollution.

3.1 Definition of water pollution:- *According to Water (prevention and control of pollution) Act 1974, water pollution means such contamination of water or such alteration of the physical, chemical or biological property of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substances into water (whether directly or indirectly) as may, or is likely to, create a nuisance or render search water harmful or injurious to public health or safety, hot to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of Aquatic organism.*

## 4. Causes of River Pollution

- **Population growth & urbanization**: Population growth and urbanization lead to increased demand for water for agriculture and household uses, which ultimately increases wastewater generation, and hence this wastewater is discarded into the rivers.
- **Untreated Discharge**: It includes ever-increasing dumping of untreated sewage, industrial effluents, and other human activities such as dumping of municipal solid waste, etc. According to a CPCB report August 2013 on "Performance Evaluation Of Sewage Treatment Plants of 35 metropolitan cities in India" it has been found that the wastewater generation of these cities was 15,644 MLD, but the treatment capacity exists for only 8040 MLD wastewater.
- **Agricultural Runoff**: Each year, 9000 tons of pesticides and 6 million tons of fertilizers are used in the vicinity of the river (WWF). These are washed out by either rain or by excess irrigation and finally enters in to the stream.
- **Mining Activities**: Mining activities releases harmful chemicals like sulfides and other toxic metals like lead, arsenic, mercury, etc., get washed off by rain, and reach the river. Types of river pollution from mining are-

a) **Acid Mine Drainage (AMD)**: When sulfide rocks react with water and oxygen to form sulphuric acid. The acid produced is carried into nearby streams, rivers, lakes, and groundwater by rainwater or surface drainage.

b) **Heavy metal contamination & Leaching**: Heavy metal such metals as arsenic, cobalt, copper, cadmium, lead, silver, and zinc, contained in the excavated rock when exposed during mining. They get leached out and carried to the river by rain.

c) **Processing chemicals pollution**: It occurs when chemicals like sulphuric acid and cyanide leach, spill, or leak, from the mining site to nearby water bodies. They are highly toxic to humans and wildlife.

d) **Erosion and sedimentation**: Rain and the flood cause erosion of the exposed earth's surface and carry considerable amounts of sediment into streams, rivers, and lakes. Excessive sediment can clog riverbeds and suffocate watershed vegetation, wildlife habitat, and aquatic organisms.

- **Open dumping**: The heaps of waste decomposes slowly, releasing toxic chemicals. These chemicals are washed off through the rainwater.
- **Burning of fossil fuels and air pollution**: Air pollutants from the burning of fossil fuel produce different gases such as Nitrogen dioxide, carbon monoxide, carbon dioxide, Sulphur dioxide, etc.; these gases react with water in the atmosphere and result in the formation of acid rain.
- **Mythological and religious believing:**

a) **A holy dip in Kumbh:** In Kumbh Mela, about 82-100 million people gather to take a holy dip in rivers, drastically increases the BOD of those rivers. A study conducted by CPCB showed that during the Kumbh Melas, the fecal coliform count increased up to 200 times than the normal count.

b) **Idol immersion (Murti Bisarjan):** In a study conducted by the CPCB, entitled "Impacts of Dusshera Festival on the River Hugli," suggests that at least 15,000 idols of Goddess Durga are immersed in the Hugli, releasing 16.8 tonnes of varnish and garjan oil and a whopping 32 tonnes of various colors.

## 5. Effects of river pollution

The effects of water pollution are summarized below:

- **DO reduction and BOD increment**: The addition of organic or inorganic pollutants to the water bodies causes DO reduction, which further increases BOD and finally, a situation comes when no oxygen is available for other aquatic organisms, and they start dying.
- **Eutrophication**: It is the enrichment of water bodies with nutrients such as nitrate, phosphate, phosphorus, etc. Due to the excess availability of nutrients, the microflora of river grows in excess, causing death of another aquatic organism in the river.
- **Bioaccumulation**: When toxic chemicals get their way into the river water, they enter the plants and aquatic organisms through the food chain and accumulate in each level.
- **Biomagnifications**: It is the accumulation of chemicals in the body of organisms in higher concentrations as it reaches higher trophic levels.
- Spread of diseases such as **Minamata**, **blue baby syndrome** or **methemoglobinemia**, **fluorosis**, **Diarrhea, Dysentery**, **Cholera**, **Typhoid,** and many more.
- Dyes from textile industries induce mutation in animals.
- **Frequent flood**: Due to the pollution of rivers with excessive solid dumping, siltation triggers, which reduces the course of the river causing frequent floods.
- Dying of distributaries and stream due to deposition of silt and other solid wastes such as plastics, sacks, rags, etc.

- **Loss of Biodiversity:**
    a) **Gangetic Dolphin** is now an **endangered species** due to the excessive pollution of the rivers. Likewise, many organisms are killed, and species are destroyed due to river pollution.
    b) **A threat to Freshwater Turtle**s- they are the oldest of all living reptiles and have evolved little in the 200 million years; they are very sensitive to water pollution.
    c) **Coral Reefs destruction:** Polluted river draining into oceans carries huge quantities of deposit from land-clearing, nutrients from the agricultural field and sewage outflows, and pollutants such as petroleum products and pesticides. These land-based sources of pollution threaten coral reef health.

- **Greenish-Black patches on the Taj Mahal**: Pollution from the river has been found responsible for green spots on the Taj Mahal. Pollution and pools of stagnant water body have turned the Yamuna into a breeding ground for insects that are sullying the white marble of the 17th-century monument and world's 7th wonder. According to a report by Archaeological Survey of India (ASI), negligible water flow in the Yamuna behind the Taj Mahal and the area turned into a swamp with massive algal growth, and the available phosphorus is the primary sources of food for this particular species of insects (*Goeldichironomus*).
- **Water scarcity**: The rivers are the source of freshwater, and if its pollution is not stopped, we will face water scarcity throughout the country.

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# Efforts taken by Green Habitat to revive the Canoli canal, Chavakkad, Thrissur District, Kerala

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Water pollution is one of the most serious ecological threats we are facing today. Water pollution is the contamination of water bodies, usually as a result of human activities. For example, releasing inadequately treated wastewater into natural water bodies can lead to degradation of aquatic ecosystems. Pollution is the result of the cumulative effect over time. There are mainly three types of contamination through which way a waterbody can be polluted, those are physical, chemical and biological contamination. Water pollution happens when toxic substances enter waterbodies and the largest source of water pollution in India is untreated sewage.

Water is one of the most important natural resources required for sustaining life on Earth. It is a vital resource that is becoming increasingly scarce due to rapid increase in population, industrialization, urbanization, climate change and various other anthropogenic activities (Xiao *et al.* 2016). Water is threatened with pollution from various sources viz., domestic wastes, industrial wastes, agricultural wastes, run off from urban areas and soluble effluents. All of these contaminants can find their way into local water bodies, and subsequently lead to the water quality problems (Rohitashw and Raj, 2018).

Kerala state, in South of India has a rich source of water bodies, with ample rivers, lakes; streams and most importantly back waters. However, these water bodies over the years are getting polluted due to rapid urbanization. Water pollution became rampant in the state because there is no proper waste management system. Rivers in Kerala face the problem of pollution caused by municipal wastes which include liquid, solid, industrial effluents and agricultural runoffs. There is no efficient water treatment system especially in municipalities and hence pollution level in some of the sites is far above permissible limits. Some of the recent studies on water pollution in Kerala are by Badusha and Santosh (2017), Fehmida and Bindu (2018) etc.

In Kerala there is a canal named Canoli canal, which is the longest man made canal. The canal runs almost the entire length of Kerala from Kohikode district in North to Kochi in the south of Kerala. Its' construction was completed in the year 1848 and till 1950 it remained a busy trading port. The canal was constructed for inland water transport along coastal Kerala. After the road transport system was well developed, the canal lost its importance and trade through the canal diminished over the years. This ultimately led to the deterioration of the canal.

Illegal encroachments became rampant over the years and waste disposal into the canal became common. Apart from this dumping of waste, destruction of canal walls, weed infestation, discharge of effluents and water from septic tanks etc. was rampant. Not only domestic wastes are released but the canal is also being indiscriminately used as dumping ground for large quantity of solid wastes. Septic waste has also been a major source of pollutant at several points of the canal. Industrial effluents are also contributing to the pollution, though it was very less effective reason than other reasons. Water hyacinth at many points in the canal, block the canal from its natural flow. The canal is now unfit for transport because of pollution, encroachment and long periods of disuse. Canoli canal opens in to estuary; on both the sides in Chavakkad, hence tidal amplitude affects the flow of water. In summer the water is highly saline and in other seasons especially monsoons the salinity is low.

There is dire need of restoring this old water way of Kerala for its heritage and make it a tourist destination and hence Green Habitat, an NGO dedicated to conservation initiated program to revive this canal. The program was initiated in Chavakkad taluk which is in Thrissur District of Kerala. In this regard communication was established to all the stake holders of the Canoli canal such as local communities, local fishermen, general public, educational institutions etc. The main thrust and area of focus was making school children aware of the importance of the Canoli canal as they hold the future.

Green Habitat as part of revival of the Canoli canal and for improving the health of the canal started many initiatives.

One of the initiatives was to carry out boat trips through the entire stretch of the Canoli canal in Chavakkad thaluk and manually clean the canal of plastic waste such as bottles and bags. Apart from this algal growth and other floating plants such as water hyacinth were removed, which are the main reason of blocking of the flow of water. The canal was cleared of any blockage in the path like fallen trees etc. Bins for collecting plastic were set up. Even signboards were installed at many locations to discourage people from disposing waste in the canal. Awareness program were conducted with the help of panchayat and local clubs in this regard. Slaughter house, hotels and houses along the banks were discouraged from releasing their waste in to the canal. Efforts are also being made to introduce grass eating fish. In all such activities the local fishing community was involved and they cooperated to the fullest, as it was a matter of their livelihood. Earlier the canal was abundant with fishes, but the fish catch has dwindled over the years due to pollution.

The main activity which Green Habitat takes pride in, is the plantation of mangroves along the canal. Mangroves have grown substantially making the banks of the canal greener (Figure 1). Ultimate success would be achieved if the canal goes back to its old glory and be used as a mode of transport especially as a tourist attraction and destination by plying boats in the canal. Efforts are being made in this direction by involving the authorities.

**Figure 1. Canoli Canal, Chavakkad, Kerala**

Studies on the river ecosystems indicate that the major Indian rivers are grossly polluted, especially beside the cities (Srivastava, 1992). Hence each water source should be monitored with utmost care and precision for laying down strategies for the effective conservation and management of the pristine water resources (Badusha and Santosh, 2017). The contamination of groundwater leads to ecological degradation, loss of vegetation, and pollution of surface water sources causes adverse effects on human and animal health (Fehmida and Bindu, 2018)

Water pollution control requires action at all levels of the society. Public education, recycling and proper disposal of household chemicals and wastes and proper maintenance of onsite septic systems to reduce nutrient loading are some of the solutions which can be taken up. Green Habitat intends to conduct a biodiversity study of the Canoli canal, to create a data base of its flora and fauna and also to conserve the same.

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## Sea Level Rise and Salt Water Intrusion

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Sea-level rise (SLR) is one of the most apparent climate change stressors the human society is facing today. Sea level has risen approximately 1.2 mm/year over the last 100 years (Hennessy et al. 2004) and is projected to increase up to 80 cm by 2100 relative to 1990 sea levels (IPCC 2007). Nowadays, saline water intrusion due to SLR has been gaining its significance as the major concern around the world, especially in the urban coastal area. Water pollution due to salt water intrusion has major impact on human being and their livelihood. It is mainly due to static fossil water and the dynamics of sea water intrusion. It arises when water from the aquifer is depleted faster than it can rejuvenate. Lower precipitation level and warm temperatures can also play an important role in saltwater intrusion due to the lack of groundwater availability and increased evaporation (Figure 1). Millions of individuals in India use groundwater for domestic, industrial and farming purposes. Four Indian cities such as Kolkata, Mumbai, Surat, Chennai are among 45 such coastal port cities globally where even an increase of sea level rise by 50 cm will lead to flooding and increasing the threat to low lying coastal cities and small islands.

Agriculture, aquaculture and fisheries production can be influenced due to salt water intrusion. Due to salinization, health security will increase in cholera outbreak, hypertension and increased breeding of salinity-tolerant mosquitoes. Invasion of seawater into freshwater and brackish areas would cause major impact on coastal groundwater resources (freshwater aquifers) along low-lying coastal areas. Saline water intrusion due to SLR would thus be a serious problem both at the local and global level since 80% of the world's population live along the coastal areas and utilize local aquifers for their water supply (Kibria et al. 2016). Furthermore, SLR is projected to increase the frequency of storm surges resulting to flood and thousands of kilometers of coastlines along the world's oceans will cause to contaminate both boreholes in inundated low-lying areas (Carlson et al., 2007). Significant rice field area is projected to be inundated in several countries, most remarkably in Southeast Asia, South Asia, and East Asia (e.g. Vietnam, Egypt, Myanmar, and Bangladesh) (Dasgupta et al., 2009). However, SLR also can form in new regions for brackish water in fish/shrimp aquaculture. SLR induced salt water intrusion can increase the threat of cholera in many countries through cholera bacterium, Vibrio cholerae, which survive longer in salinity range from 2.5 ppt to 30 ppt and need sodium ion (Na+) for their growth (Borroto,1998). Moreover, SLR may cause replacement of the most dominant, freshwater-loving important tree species in the Sundarbans, West Bengal. Sundari trees (Heritiera fomes) and also other salt tolerant trees such as Goran (Ceriops decandra, C. tagal) and Keora (Sonneratia apetala) (World Bank 2000) would be affected in future. According to Wong et al 2013**,** globally major areas of coastal and estuarine floodplains is underlain by sulfidic sediments and acid sulfate soils (ASS). These sediments frequently contain high concentrations of acidity and trace metals. Water tables in these environments are often close to the surface and intercepted by relatively shallow drains. Due to their low elevation and locations, these floodplains are highly susceptible to pulses of saline water caused by saltwater intrusion, storm surge and rising sea levels. Extensive drainage system construction has further increased the susceptibility of the floodplain to saltwater inundation by increasing connectivity to the estuarine channel. SLR in combination with tide events will cause flooding and septic tank seepage, resulting in mobilization of fecal coliform bacteria and other contaminants.

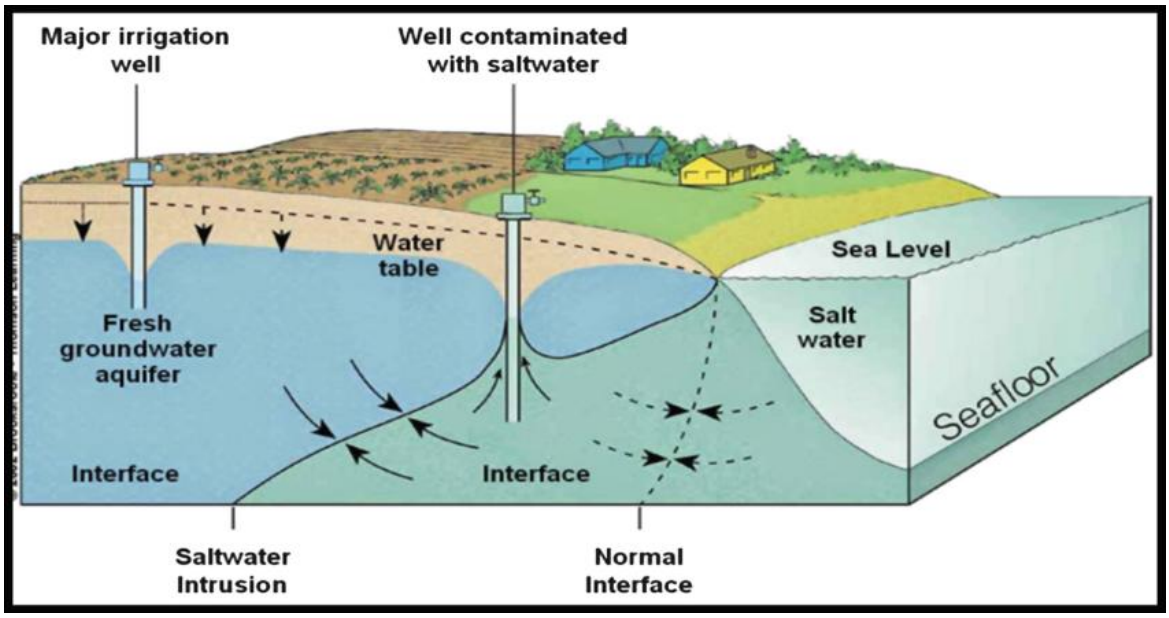


**Figure 1 The process of sea water intrusion (Ismail 2018)**

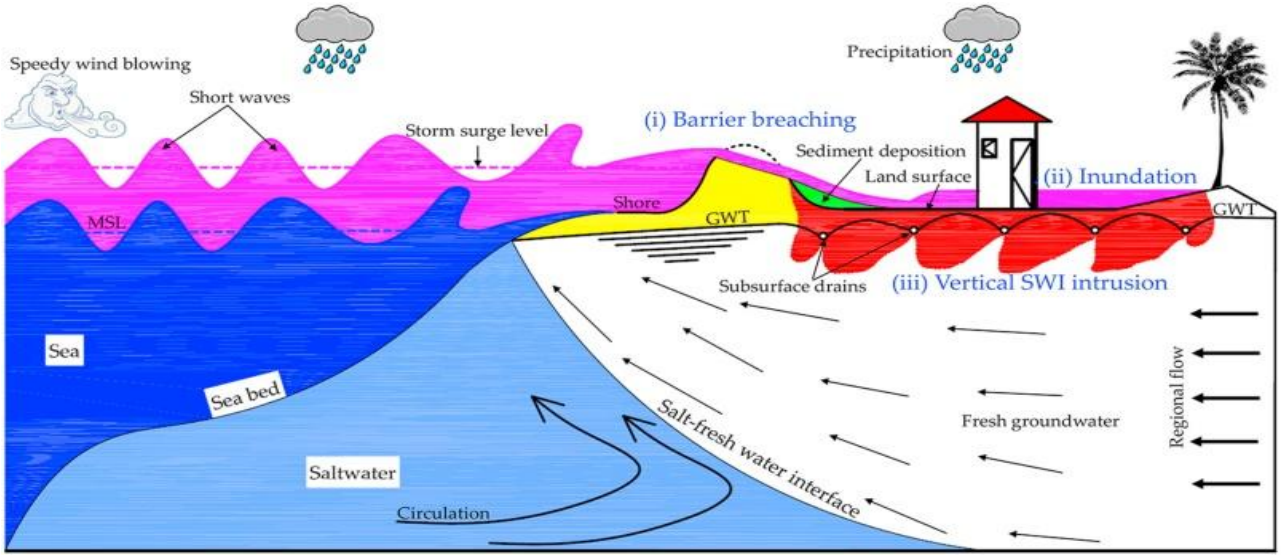


**Figure 2 Illustrations of roles of the subsurface drainage in enhancing the resilience of coastal aquifers against coastal floods (*Source:* Elsayed & Oumeraci, 2018)**

Many scientific investigations claimed that ground water and surface water is getting polluted with the salt water intrusion in different areas of India. A study by Mohanty and Rao, 2018 on ground water chemistry and salinization in Puri district of Odisha found the values of oxygen isotope (δ18O) between −5.3% to and −2.96%, which indicates groundwater compositions were influenced by the evaporation process. Based on Cl− concentrations (0.4–35 meq/l), the saline end-member is mixing of seawater with the groundwater.

A study by Singaraja, 2015 has been attempted in the hard rock aquifer of the south-eastern part of India. The Piper and chadda's plot shows that most of the groundwater samples fall on Na–Cl water type may be due to saltwater intrusion in the eastern part study area. The results further reveals that about 30% of the groundwater samples were strongly affected by the saline water in those areas. Sophiya & Syed 2013 assessed vulnerability to seawater intrusion in the Ramanathapuram district of Eastern India. Results revealed a severe increase in percent area coverage under moderate vulnerability, from 19.5 to 53.88 %, between the years 2001 and 2010. Kanakraj et al 2018 carried out a study in Chennai to determine the hydro-geochemical processes and influence of seawater intrusion in the coastal aquifers using geophysical, geochemical, and stable isotope techniques. The results reveal that EC, Na+, and Cl- were high in groundwater of wells near salt pan, Buckingham Canal, and backwater regions. Further they found that around 45% of the groundwater of this study area is of Na+-Cl- type due to salinization. The management of coastal aquifers requires careful planning of withdrawal strategies for control and remediation of saltwater intrusion. Prediction and control of future saltwater distribution in coastal aquifer may be possible by simulating the processes utilizing various mathematical models. Community awareness and education on the sea-level rise would be vital. Government and private sectors should formulate appropriate policies and actions to reduce emissions of greenhouses, that causes climate change and sea-level rise. Both climate mitigation to reduce emissions and adaptation to deal with rising sea levels that cannot be avoided will be needed. Adaptation offers many possible measures, when those would be planned appropriately, could be possible to have highly effect in managing coastal risks and impacts.

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# Seasonal Variation in Physicochemical quality of Lonar Lake Water

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## ABSTRACT

*The Lonar crater situated in Buldana District, Maharashtra is natural hyper saline lake formed by hypervelocity meteoritic impact in basaltic rock. An attempt has been made to evaluate physicochemical qualities of Lonar Lake water. Water samples were analyzed from 2017 to 2018 for seasonal variation in physicochemical qualities of Lonar lake water and revealed that, the water is alkaline (pH 10.5) and characterized by high concentration of Salts (9060mg/L), Alkalinity (5786 mg/L), Salinity (6391 mg/L), Total hardness (480 mg/L) and Dissolved Oxygen (0.034 mg/L). The data indicated that the alkalinity is increased in monsoon and post-monsoon season while decrease in pre-monsoon season. Likewise the chloride and salinity is increased in pre monsoon season while decreased in monsoon and post-monsoon season. As the Lonar Lake is unique in the world for its alkalinity and salinity of the water but its alkalinity, pH and salinity goes on decrease day by day. Hence this World heritage should be preserved for its alkalinity and salinity.*

**KEYWORDS: -** Ramsar Site, Integrated Lake Basin Management etc.

## INTRODUCTION

The Lonar Lake, situated in the Buldhana District of Maharashtra State, India, is located at 19° 58'N, 76° 31'E. Lonar Lake, often described as the geological wonder, which ranks third in the world amongst the craters created by the meteorite impact, Water is directly related to human beings. Visitors and pilgrims use the water of 'Dhar' (a natural fresh water flow in lake) and 'Sitanahani' for bathing and washing besides drinking and discharge of sewage from hotels, stales released directly into the lake water, which deteriorate the quality of water. Another source of pollution is wastes thrown by visitors and pesticide residues from the crop fields after the rains. The World Lake Vision (WLV) advocated an integrated approach for protection and conservation of Lakes for their sustainable use by Integrated Lake Basin Management (ILBM). It has proposed seven basic principles to accomplish the task of lake management.

The implementation of these principles will surely help to achieve the goal of conservation of Lonar Lake in future. On this background, management measures based on seven principals advocated by World Lake Vision (WLC) have potential to create a lake based civilization where these resources will meet all the human water needs at the same time maintaining their ecological integrity and will be a source of esthetical beauty and inspiration for creativity and spiritual fulfilment. *Walter Rast and M. S. Kodarkar* (2008)

**Figure 1: General view of Lonar Lake and site**

## MATERIAL AND METHODS

Seasonally water samples were collected from four sampling site of Lonar crater in 5 L bottles and carried to the laboratory. Sampling was done monthly in the morning in 2017 to 2018. The parameter selected for analysis were water temperature, pH, total dissolved solids, total alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, dissolved oxygen. The pH, temperature, DO, salinity, and TDS were determined on the spot by water analysis kit and rest of the parameters were analysed in the laboratory by standard methods *APHA*

## RESULTS AND DISCUSSION

In this study water samples were been collected from Lonar Lake in pre-monsoon, monsoon, and post-monsoon season. These water samples were analyzed for the seasonal variations in physicochemical quality of Lonar Lake water.

The numbers of physicochemical parameters like pH, temperature, total dissolved solids, alkalinity, dissolved oxygen, chloride, salinity, total hardness, calcium hardness, magnesium hardness were performed.

In the present study the data revealed that there were considerable variations in the quality with respect to their physicochemical characteristics. Physicochemical analysis of Lonar Lake water was studied in different season (2017 to 2018). It is also observed from the present study that; the color of the lake water is also pale green to dark green because of the dense algal population with predominating *spirullina.* The odour of lake water is somewhat offensive. *Muley and Babar* noted the offensive odour of the lake water. The lower pH during rainy season may be due to dilution of alkaline substances in rainy season, and resulting in increase in turbidity of the water which in turn reduced photosynthetic activity of algae. *Thakker and Ranade* observed the pH 9.5 to 10.0 and *Dabhade et al* recorded it from 10 to 10.5.

A review of literature revealed that its salinity was 40.78, 31.52, 30.87 in 1910, 1958 and 1960 respectively. The salinity of the lake is now lowered down to 7.9% (*Joshi A. A. et al*, 2006). The depletion in dissolved oxygen values during monsoon and post-monsoon season are due to the tremendous growth of the planktonic community of the lake. Low dissolved oxygen of the lake is indication of the presence of organic matter resulting in higher Biological Oxygen Demand. The "algal bloom" is an adequate to explain the presence of planktonic community of Lonar Lake. It is not only suspended in the columns of water but has formed scum over the surface of lake water which does not allow the atmospheric oxygen to get dissolve in lake water. Whatever the oxygen produces by phytoplankton through respiration might be utilized by zooplanktons and other macro-invertebrates. (*Dabhade et. al*, 2006) observed the dissolved oxygen from 1.1 mg/L to 4.87 mg/L (Table 1). *Dabhade et al* recorded that the total hardness was slightly fluctuating and in range of 150 mg/L to 350 mg/L.

The Naturally determined environmental conditions and persistent human intervention have caused eutrophication and have led to senescence of the lake bringing in to the brink of a death *(Khobragade Kshama*, 2003)

Alkalinity values of lake water at different sampling stations are much greater; from this it can be inferred that the lake water is highly alkaline and it is ascribed to an interaction between sodium chloride, calcium carbonate and water stagnate over a long period of time *(Malu* 1999).

It can be concluded from the study, that alkalinity is being increased in monsoon and post-monsoon season while decrease in pre-monsoon season. Likewise, the chloride and salinity is being increased in pre monsoon season while decreased in monsoon and post-monsoon season. Lonar crater is coming under threat as result of unchecked sewage flow there has been increased in Lake water level in the lake decreasing its salinity level such change also effect ecosystem.

**Table 1: Average of Seasonal variation in Lonar Lake Water in year 2017 - 2018**

| Average of Seasonal variation in Lonar Lake Water in year 2017 - 2018 | | | |
|---|---|---|---|
| **Parameter** | **Pre- monsoon** | **Monsoon** | **Post- monsoon** |
| **pH** | **10.5** | **10.3** | **10.2** |
| **Temperature ( °C)** | **29** | **28** | **27** |
| **Total Dissolved Solid (TDS)** | **21800** | **12460** | **10400** |
| **Alkalinity (mg/L)** | **4213** | **5786** | **4390** |
| **Chloride (mg/L)** | **2414** | **2816** | **1442.5** |
| **Salinity (mg/L)** | **6455.21** | **4388.98** | **5246.31** |
| **Dissolved Oxygen (mg/L)** | **0.03** | **0.07** | **0.02** |
| **Total Hardness (mg/L)** | **486.37** | **588** | **432.08** |
| **Calcium hardness (mg/L)** | **2414** | **2186** | **1442.5** |
| **Magnesium Hardness (mg/L)** | **658** | **1043** | **64.19** |

**Emerging Changes found in Lonar Lake**

The Lonar Lake has been marked as one of the saltiest body of water. The salinity of the water was so high that nothing could survive in it except some micro-organisms.

The present investigation shows a change in the Biodiversity of the lake, the changes is found in individual, Habitant, populations and interaction between biotic-biotic as well as biotic-abiotic resources and population ecology. Due to negative impact on alkaline nature of water the Phytoplants is also changed. The change is observed in population and Habitat. To some extent the change at a considerable rate thus the alkalinity and pH of water is changed. From samples collected from four different stations up to 4 meter and below 4 meter shows different parameters.

The ratio of DO is found less up to 4 meters. The $K_mNO_4$ and hydrogen sulphide is observed below 4 meters, maximum. Some micro-organisms and bacteria generally found in fresh water are also present in the lake water thus a fear is felt that in near future the saltiness of water body (Lonar Lake) may transform into fresh water.

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# Water Pollution: Challenges it poses to manage a bird sanctuary in urban landscape (National capital region of India)

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The following picture might give a feeling of snowflakes in a valley, but knowing the location, clearly, we are at loss. It is the Yamuna River in Delhi (NCR) where the chemicals, including detergents, give a common sight to citizens of the capital.

With the ever-burgeoning urban sprawl, maintenance of greenery and dependent fauna is incumbent on urban dweller needs their tolerance towards them. The aesthetic and recreational value of a green space and promotion of green muffler provides inadequate reason as well as very less respite to "urban biodiversity". The flora and fauna for such concrete jungle, are suffering invariably at the expense of infrastructure expansion. Though with each year, the fast losing battle of conserving nature is getting attention and its consequences are proffered. But these researches are more focused on divided strategy for urban, rural and forest landscape and hardly cater to the co-existence in case of overlapped strata.

The Okhla Bird Sanctuary (OBS) is no exception to this challenge. Being a part of the Delhi urban agglomeration (DUA), the protected area has a disarrayed identity. On 8$^{th}$ May 1990, the Uttar Pradesh government declared 400 ha of wetland as a bird sanctuary.

The man-made reservoir is famous amongst bird watchers since 1940's and currently it is attracting denizens of Delhi as well as surrounding area; though its popularity is not spread far from National Capital Region (NCR). H. P. W. Hutson recorded the birds of Okhla during the course of his ornithological surveys in the Delhi region (June 1943 to May 1945). Subsequently, Mrs. Usha Ganguli also recorded the avifauna from this site in her book, *A guide to the birds of the Delhi area* (Ganguli 1975). Dr. A.J.Urfi has been monitoring the avifauna of this region since 1989 and has published many articles. Presently this area has been identified as Important Bird Area (IBA). It has more than 20,000 birds and presence of globally threatened species. Flamingoes and Bar headed goose have always been an attraction for tourists. A lot has been said about these flying visitors as well as residents of OBS, especially by enthusiasts of Delhi Bird Group which maintains a regular nature walk in the sanctuary and also contribute to the knowledge and understanding of the avifauna. Forest department conducts water-bird count every year in the winters when migration is at its peak. Wetland International and BNHS also organize Asian Waterfowl Count every year.

The birds like Spot-billed duck, Northern Shoveller, Gadwall, Common Shelduck, Comb Duck, Common Teal, Tufted Duck, Common Pochard, Greylag Goose, Bar-headed Goose, Northern Pintail, Ruddy Shelduck, Garganey, brahminy ducks, pied avocets, whiskered terns, green sandpipers, wood sandpipers and ruffs are reported from OBS. According to Urfi (Delhi University), bird species recorded since 1992 included three vulnerable species (Baer's Pochard, Indian Skimmer and Bristled Grassbird) and six near threatened species (Ferruginous Pochard, Black-bellied Tern, Darter, Black-headed Ibis, Painted Stork and Black-necked Stork). He also observed that OBS is an important feeding ground for 300 to 500 Painted Storks that breed in Delhi Zoo.

During one of my visits to Delhi-side area of OBS by boat, some thirty bar-headed goose was observed. However, the site of their occurrence in the lake looked like huge kitchen dumping ground. A lot of organic waste which found its way to the lake through municipal and sanitary waste served feeding site for the Goose. Also once figuring out what all grass birds must be around, I got startled by seven nilgai deciding to bring turmoil in the turbid water by their race across Yamuna. The sighting of flamingoes on a winter morning provided me a very enthusiastic and good start of the day.


In spite of providing refuge to many native as well as migratory birds, it fails to enjoy privilege of a sanctuary. The interstate boundary provides major constraint in the management of the OBS. Though its location has an added advantage of drawing tourists from two different states but the inadequacy of involvement and communication amongst various stakeholders fails it. The Okhla barrage (which forms the sanctuary) is maintained by irrigation department and provides water to Agra canal. The level of water maintained in the barrage depends on the demand of water from U.P. and on the amount of water released from Wazirabad barrage which is 22km upstream of Okhla. Post tapping of treated water at Wazirabad barrage for water supply in Delhi, Yamuna imbibes various sewage and drains including the Hindon River from U.P which joins the Okhla barrage upstream at Hindon cut. Shahadra drain joins Yamuna just downstream of barrage. The industrial as well as sewage waste has been called one of the major cause of decreasing number of birds in sanctuary. The 22 km stretch of Yamuna through Delhi becomes highly polluted and majorly contribute to the pollution load of Yamuna river (CPCB 1999). The water quality of Okhla barrage corresponds to category of "moderately polluted class", and have indicated very low DO (2.26 ± 1.62 mg/l), high BOD (15.20 ± 3.75 mg/l) and COD (44.60 ± 12.07 mg/l), along with high levels of phosphate (0.64 ± 0.13 mg/l) in the water, showing heavy organic pollution and algal bloom in the wetland (CPCB 2011, Manral & Khudsar 2013). A study involving remote sensing and field data concluded abrupt increase in organic pollution content downstream of Wazirabad barrage resulted in very high BOD levels (Said, 2019). The fluctuations in DO level from nil to well above saturation levels suggest eutrophic conditions (Tiwari and Shanmugam 2011).

The pollution level in yamuna at Okhla barrage is affecting many birds, aquatic animals and humans. In 2018, thousands of dead fish were found floating in Kesi Ghat and Vrindavan which was claimed to be post release of 3000 cusecs of water from Okhla barrage (Times of India, Nov 3 2018). The presence of heavy metal in yamuna river is reported which is reaching human foodchain through vegetable. "The concentration of heavy metals was found to be highest in spinach, followed by cauliflower and the least in radish" (The Hindu, February, 2012). Religious activity like Purnima Snan, Chhath Pooja, Murty viserjan, disposal of domestic of Residual mortal remains of dead bodies and disposal of domestic pooja / yagyan remains are the large issue to put impact on the pollution of river and the population of Delhi is also considerably high, as well. Being religious river, thousands of devotees gather in Yamuna in NCR during 'chhatth poja' and take holy dip in the polluted river which affects their health, but also during the process they contribute further to the pollution (India Times November 2019). As there is no filtration system on the waterbody before entering the Okhla bird sanctuary, a lot of such pooja material, cracker residue etc. form a permanent component to the habitat of bird sanctuary. Silent Spring of Rachael Carson discusses about bioaccumulation, however in Yamuna River, there is a dearth in study to understand the pollutant in water and bioaccumulation in bird ecology. The heavy metal pollutant presence and its' bioaccumulation in food chain affects the birds in various ways which needs to be documented as these birds are migratory and the waterbody should be treated too.

The irregular maintenance of water and polluted water which is increasing the spread of *water hyacinth* in barrage is not conducive for nesting water birds. The water level maintenance obliges to the water demand and not to the level necessary for fish and diving birds. The Brahminy duck and northern shoveler which is common visitor for the sanctuary start avoiding the place due to water irregularities. Their nesting habitat is also being replaced by *Eicchornia* (water hyacinth) a native of Brazil and invasive to India. The water hyacinth mats have been found to reduce oxygen level underwater eliminating fish and also block the sunlight for reaching the underside of water reducing the flora.

Delhi being capital of the country, has been burdened with higher development dependencies compared to other urban areas resulting which the sustenance of an urban protected area here faces much heightened challenges.

The protected area in an urban landscape has an ecological role which is lost in oblivion shrinking to the status of a "green space". The extended habitat in the surrounding of such area, help in increasing the groundwater recharge, providing refuge to many faunas which in turn help in increasing the fauna too. The sanctuary provides educational outreach besides the aesthetic pleasure. The realization that most of the developing countries will be harboring 80% of the urban population of the world by 2030, the onus of striking a balance between development and conservation of biodiversity falls on the policymakers. Sadly, though mostly chord strikes to the tune of development and conservation of biodiversity suffers. Hopefully in the process trying to develop something we do not destroy the one which is much difficult to restore.

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# Polycyclic Aromatic Hydrocarbons (PAHs) Contamination in Creeks of Mumbai.

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Polycyclic Aromatic Hydrocarbons (PAHs) are ubiquitous contaminants in the environment with known or potential toxic, mutagenic or carcinogenic properties (Cao *et al*., 2010). These chemicals are known to enter the near-shore marine environment through the spillage of petroleum, industrial discharge and atmospheric fallouts, shipping activities, stormwater drains and urban run-off etc. (Cavalcante *et al.*, 2009). PAHs has become a global concern because of the accumulation of their residues in the tissues of various species of marine organisms and their pervasive impact on ecosystems like mangroves, corals, and mudflats.

Mumbai city is one of the most heavily populated, industrialized and the sixth-largest metropolitan region of the world (Sukhdhane *et al.,* 2015). The unprecedented increase in human activities and other sources in and around has imposed considerable stress on the surrounding marine environment of the city (Dhananjayan *et al.,* 2012). Mumbai has many creeks such as Mahim, Versova, Gorai, Vashi etc. and all of these creeks are lined by mangroves on both the banks. These creeks are the most affected due to PAHs.

Creeks are vulnerable to contamination by PAHs originated from domestic and industrial wastewater discharges, shipping activities and marine operations including tanker traffic and oil production. The quality of water is deteriorating due to the release of contaminants from industries and municipal wastes. PAHs contamination is a major hazard that is a concern for aquatic life in marine sediments (Veltman *et al*., 2012).

Mangrove ecosystems are noted as important inter-tidal estuarine wetlands along the coastlines of tropical and subtropical regions, which are now exposed to anthropogenic contamination by PAHs from tidal water, river water and land-based sources (Sarkar *et al.,* 2012). The decomposition of mangrove litter and marine-related inputs also enhances the level of PAHs in the estuarine sediments (Veerasingam *et al.,* 2015).

According to Shete *et al.* (2016), PAHs accumulation was more in mangrove plant samples (leaf and root) in comparison to the surface sediment. Elevated concentration of PAH is commonly recorded in marine and coastal sediments near urban and industrial cities. Owing to their low aqueous solubility and strong hydrophobic nature, these contaminants tend to associate with particulate material in the aquatic environment, with the underlying sediments as their ultimate sink (Landrum and Robbins, 1990). According to Veerasingam *et al*. (2011), the extent of contamination can be assessed by measuring pollutant concentrations in water, sediments and marine organisms

Information on the distribution of PAHs is rather scanty and limited to only a few isolated sites in Mumbai. Some of the studies are by Sukhdhane *et al.* (2015) from Vashi creek and Chouksey *et al*. (2004) from Basssien. In these studies, it was observed that the PAHs values were much above the permissible limit. Since the coastal area in Mumbai is experiencing rapid development stage, further assessment of PAHs in all the other creeks of Mumbai needs to be conducted extensively. There is an urgent need to establish a monitoring programme for PAH level, not only in water and sediment but also in the marine organisms to ensure that any excess in concentrations is rapidly reported and necessary actions are taken. These studies can serve as an important baseline data especially in mangroves. This data can be used by decision-makers for controlling PAHs pollution in creeks. Excessive PAHs would affect adversely most of the living organisms, and hence, preventive measures should be undertaken to avoid the ecological risks.

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# Wastewater Treatment in Pesticide Industry

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## INTRODUCTION

Pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi and unwanted plants (weeds). Classification of pesticides include:

- **Algaecides** to kill and/or slowing the growth of algae.
- **Antimicrobials** to control germs and microbes such as bacteria and viruses.
- **Disinfectants** to control germs and microbes such as bacteria and viruses.

- **Fungicides** to control fungal problems like moulds, mildew, and rust.
- **Herbicides** to kill or inhibit the growth of unwanted plants, also known as weeds.
- **Insecticides** to control insects.
- **Insect Growth Regulators** to disrupt the growth and reproduction of insects.
- **Rodenticides** to kills rodents like mice, rats, and gophers.
- **Wood Preservatives** to make the wood resistant to insects, fungus and other pests.

Table 1 shows the uses of pesticides in different sectors in India and Table 2 depicts the persistence of few pesticides in soil. Since pesticides are used on a vast scale in India and persist for a longer time in soil, the treatment of water containing of these pesticides is necessary.

**Table 1. Uses of Pesticides in India**

| Sectors | Uses |
|---|---|
| Agriculture | For control of pests, weeds, rodents, etc. |
| Public Health | For control of malaria, dengue fever, cholera. |
| Other than Agriculture & Public Health | Control of vegetation in forests and factory sites, fumigation of buildings and ships. |
| Domestic | Household and garden spray, control of animals and birds. |
| Personal | For the application of clothing and skincare. |
| Material Building | Incorporation of paints, glues, plastic protection, sheeting, the foundation of buildings etc. |

**Table 2. Persistence of Pesticides in Soil**

| Name of Pesticide | Approximate Persistence |
|---|---|
| Chlorodane | 12 years (4380 days) |
| BHC (Benzene hexachloride) | 11 years (4015 days) |
| DDT | 10 years (3650 days) |
| Heptachlor | 9 years (3285 days) |
| Aldrin, Dieldrin | 9 years (3285 days) |
| Toxaphene | 6 years (2190 days) |
| Monuron | 3 years (1095 days) |
| Diuron | 19 months (575 days) |

| | |
|---|---|
| Atrazine | 18 months (545 days) |
| Simazine | 17 months (515 days) |
| Aliphatic Acid | 3-10 weeks (21 – 70 days) |
| Carbamate | 2-8 weeks (14 - 56 days) |
| 2,4 - D | 2-4 weeks (14 - 30 days) |
| Organophosphates | 1-12 weeks (7 - 84 days) |

## MANUFACTURING PROCESS

### 1. Manufacturing Process (Technical Grade Pesticide)

In the manufacturing process of technical grade pesticide (Figure 1), the reaction takes place in a reactor system, products formed pass through fractionation system and distillation. Then the pesticide formed is dried in drier and then packaged for shipment. Wastewater generated from the manufacturing process consists mainly of two streams: high COD stream and low COD stream.

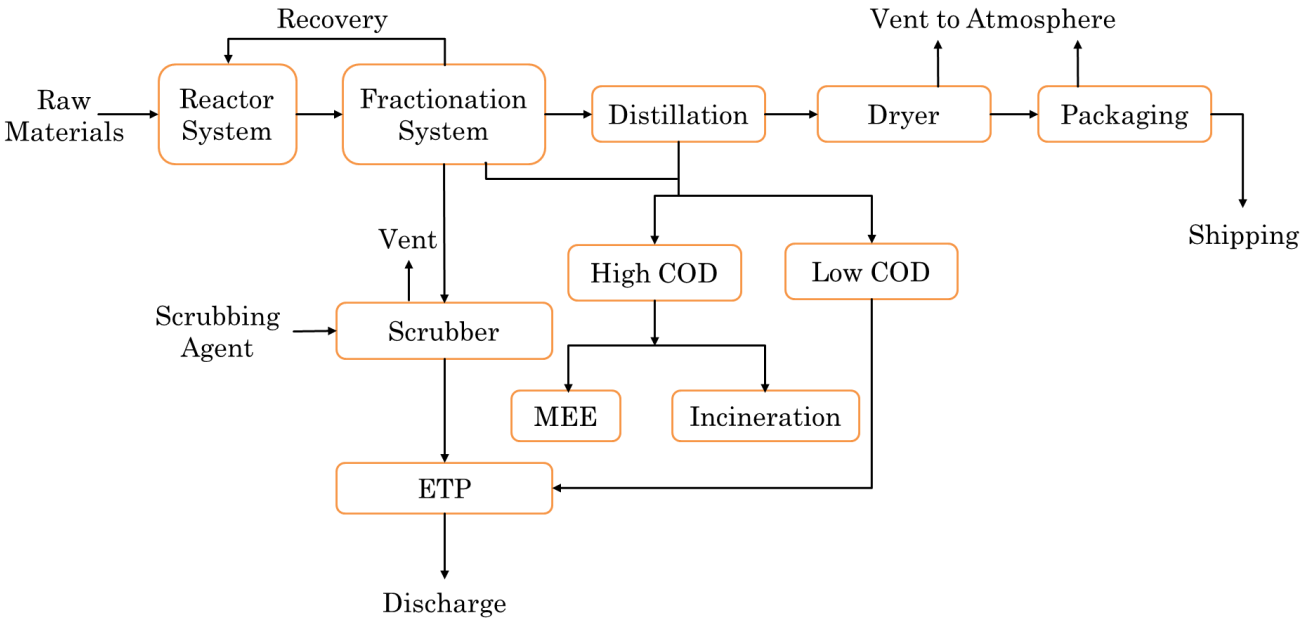


**Figure 1. Manufacturing Process of Technical Grade Pesticide**

## 2. Manufacturing Process (Formulating Industry)

In the manufacturing process of formulating industry for pesticides (Figure 2), the active ingredient and base liquid are mixed and passed through the mill. Then they are packaged for shipment. Little or no wastewater is generated in formulating industries.

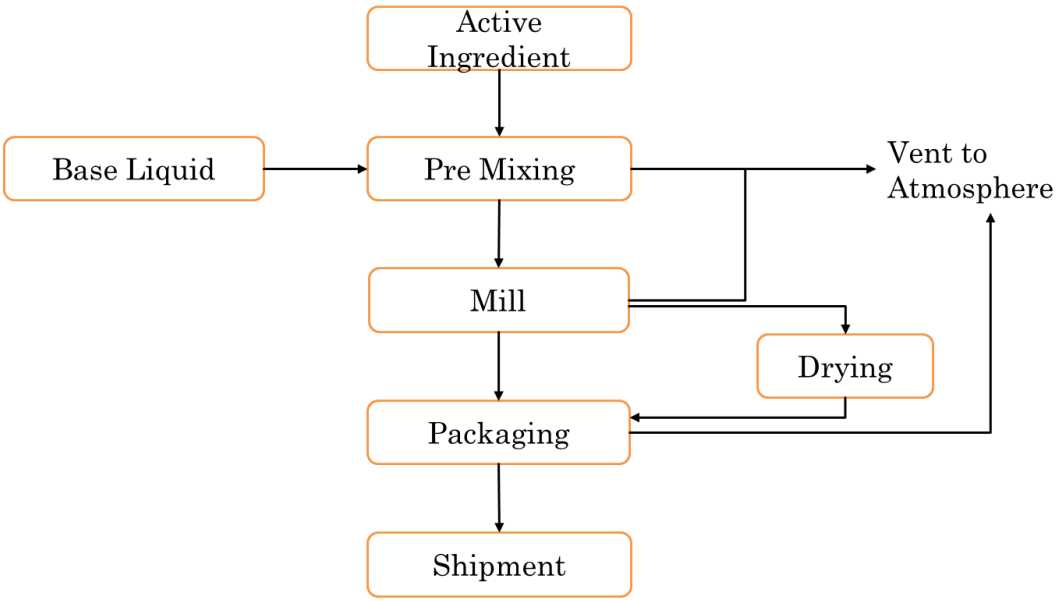


**Figure 2. Manufacturing Process in Pesticide Formulating Industry**

## WASTEWATER TREATMENT

Wastewater streams released from pesticide manufacturing plant includes:

- **Sewage**: Septic tank/soak pit or STP
- **High COD Stream:** Incineration

  COD: 20,000 mg/L and above
- **High TDS Stream:** MEE

  TDS: 16,000 or above
- **Low COD Stream:** ETP

  COD: 20,000 mg/L or below

Chemical characteristics of wastewater generated from manufacturing some of the pesticides are given in Table 3.

**Table 3. Chemical Characteristics of Some Pesticides Wastewater**

| Parameters | Pesticides (All values are expressed as mg/L except pH) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sevin | Parathion | 2-4-5 T | 2-4 D | DDT | Herbicides | Diolefin based insecticide | Discharge Limit (as per EPA Act, 1986) |
| pH | 7-10 | 2 | 7.9 | 9.5 | 0.5 – 2 | - | 2 | 5.5 - 9 |
| Chloride as Cl | 100 | 7000 | 69000 | 72000 | 11 | 30000 | High | - |
| Sulphate as $SO_4$ | 20000 | 3000 | - | - | 3840 | 5550 | - | - |
| Sodium as Na | 8000 | 6000 | - | - | - | 5550 | - | - |
| Total Solids | 40000 | 27000 | 172467 | 167221 | 6215 | 62000 | 1000 | - |
| Suspended Solids | - | - | 700 | 348 | 50 | 10 | 100 | 100 |
| COD | 10000 | 3000 | 25700 | 23600 | 3680 | 3600 | 500 | 250 |
| BOD | Nil | 700 | 16680 | 16680 | 260 | 2000 | 50 | 30 |
| COD/BOD ratio | - | 4.3 | 1.5 | 1.5 | 14 | 18 | 10 | - |
| Ammoniacal Nitrogen as N | 500 | 250 | 40 | 45 | 2.56 | - | - | 50 |
| Nitrates | - | 20 | - | - | - | - | - | 10 |

**Water Balance of a Typical Pesticide Industry**

Water is consumed for domestic purpose, industrial operations and gardening. Sewage generated is treated in STP and the recycled water is used for flushing. In industrial processes, wastewater is utilized for processing, cooling, in boiler and washing. Some fraction of water from boiler and cooling is reused and rest is sent to ETP. Water from washing is also sent to ETP. Three streams of water are generated the manufacturing process *i.e.* high COD stream, low COD stream and high TDS stream. High COD stream is sent to an incinerator, Low COD Stream to ETP and High TDS stream to MEE. From MEE, condensate released is sent to RO and the salts are incinerated. Permeate from RO is recycled and reject from RO is sent to ETP for treatment. The water treated in ETP is either disposed to CETP or reused in the industry for gardening or industrial processes.

Therefore, it works on a ZLD system. Water Balance of a typical pesticide industry is shown in Figure 3.

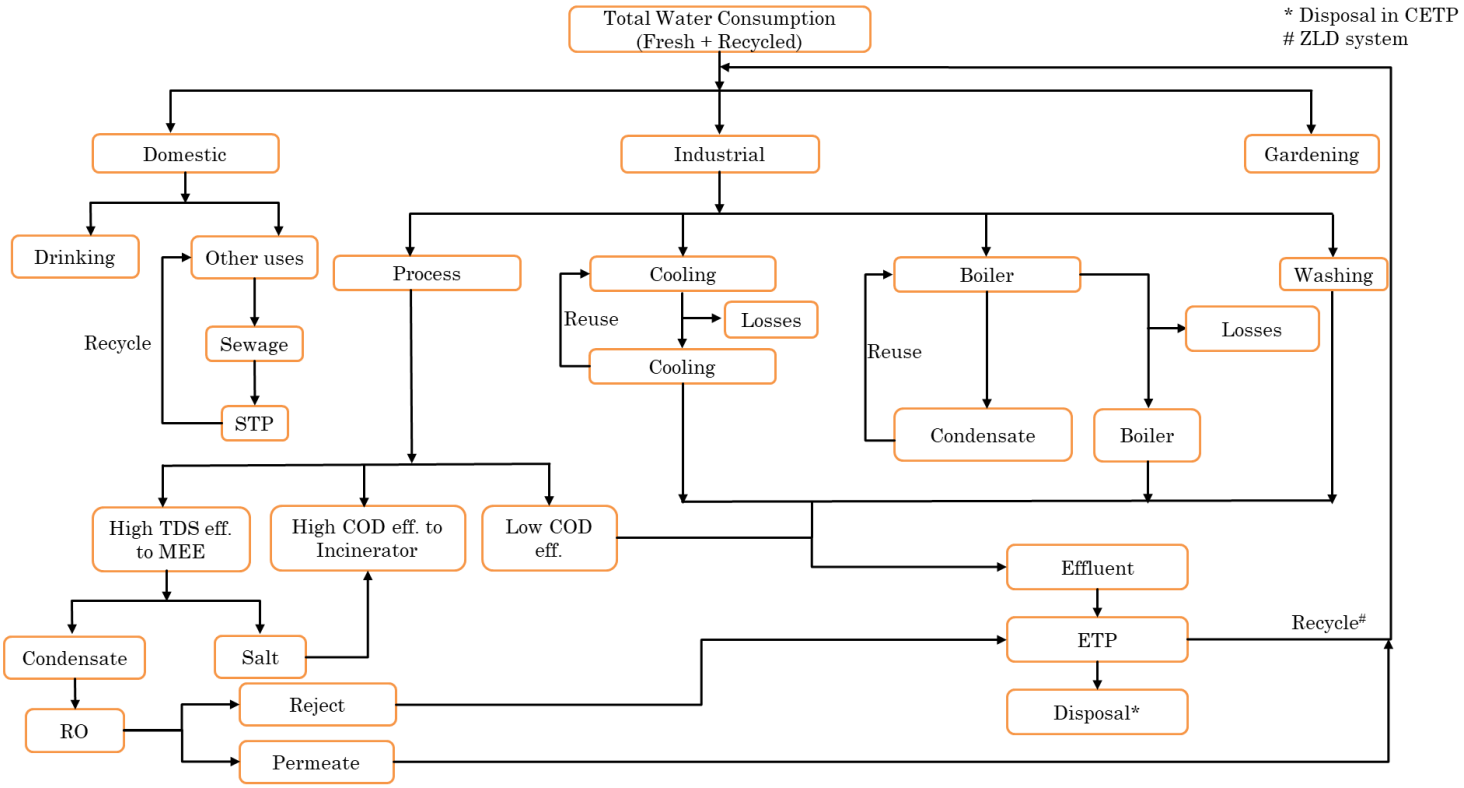


**Figure 3. Water Balance of a Typical Pesticide Industry**

Flow diagram of the effluent treatment plant for a pesticide manufacturing industry is given in Figure 4.

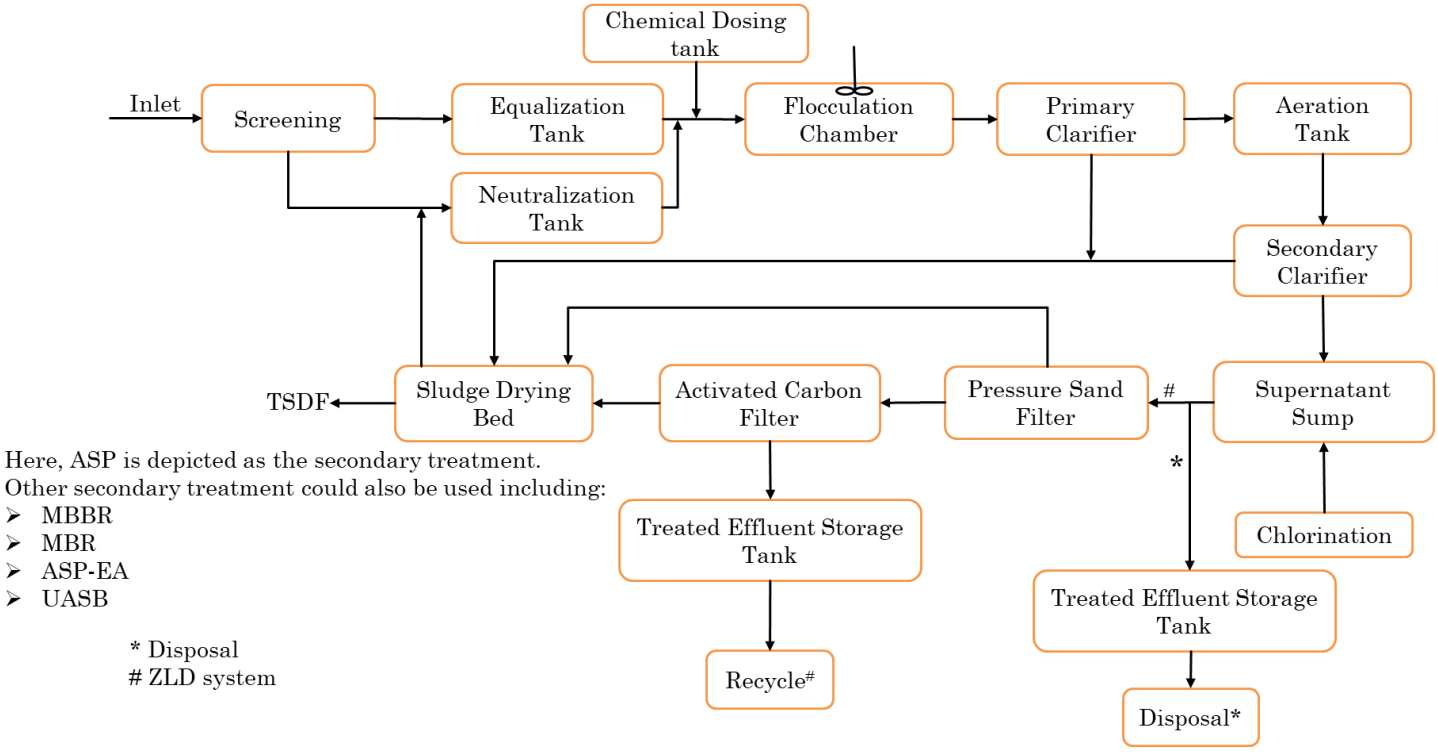


**Figure 4. Flow Diagram of ETP**

Functions of major unit operations/processes of ETP are discussed below:

1. **Screening**

The main purpose of screening is to remove solid materials that could cause damage to other process equipment, reduce the efficiency of the whole system and contaminate waterways.

2. **Equalization**

Equalization (EQ) Basins are designed to provide consistent influent flow to downstream processes by retaining high flow fluctuations. Due to the additional retention time, aeration and mixing are required in equalization basins to prevent the raw wastewater from becoming septic and to maintain solids in suspension.

3. **Neutralization**

The purpose of neutralization is to adjust pH to meet the requirements of different processing units in the wastewater treatment system.

4. **Coagulation/ Flocculation**

Coagulation/ Flocculation involves the addition of polymers that clump the small, destabilized particles together into larger aggregates so that they can be more easily separated from the water. Coagulation is affected by

- The type of coagulant,
- Dose and mass of coagulant,
- The pH level and initial turbidity of the water,
- Pre-treatment like oxidation.

5. **Activated Sludge Process**

It is the most common suspended growth process used for wastewater treatment. In the activated sludge process, wastewater containing organic matter is aerated in an aeration basin in which micro-organisms metabolize the suspended and soluble organic matter. Part of organic matter is synthesized into new cells and part is oxidized to $CO_2$ and water to derive energy.

In the activated sludge systems, the new cells formed in the reaction are removed from the liquid stream in the form of a flocculent sludge in settling tanks. A part of this settled biomass, described as activated sludge is returned to the aeration tank and the remaining forms waste or excess sludge.

6. **Chlorination**

Chlorine is one of the most versatile chemicals used in water and wastewater treatment. This powerful oxidizing agent is used for disinfection, control of microorganisms, removal of ammonia, colour reduction, destruction of organic matter, hydrogen sulphide oxidation, iron and manganese oxidation.

7. **Filtration**

a) **Pressure Sand Filter**

The Pressure Sand Filter consists of multiple layers of sand with a variety in size and specific gravity. These filters are designed to remove turbidity and suspended particles present in the feed water with minimum pressure drop.

**b) Activated Carbon Filter**

Carbon filtration is a method of filtration that uses a bed of activated carbon to remove contaminants and impurities, using chemical absorption. Each particle/granule of carbon provides a large surface area/pore structure, allowing contaminants the maximum possible exposure to the active sites within the filter media.

**8. Sludge Drying Bed**

Sludge Drying Bed (SDB) is the most widely used method for sludge dewatering. Sludge drying involves natural ways of drying to mechanical ways of removing water content.

**9. Incineration**

It is a waste treatment technology, which includes the combustion of waste for recovering energy.

**10. MEE (Multi-Effect Evaporator)**

A multiple-effect evaporator is an apparatus for efficiently using the heat from steam to evaporate water. Evaporation occurs in three steps:

- Pre-heating of a solution prior to evaporation.
- Removal of water as vapour by steam heating.
- Condensing the vapour removed.

## CONCLUSION

The pesticide manufacturing industry is one of the major sectors in India. The wastewater produced from the manufacturing of pesticides is highly toxic in nature. Majorly three streams of wastewater are produced by the manufacturing process *i.e.* high COD stream (incineration), high TDS stream (MEE) and low COD stream which is treated in Effluent Treatment Plant. The industries may work on the ZLD concept by reusing the treated water from ETP and condensate from MEE in gardening and industrial processes.

# Water Pollution & Scarcity: A Global problem

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## INTRODUCTION:

We are surviving on Earth because of three basic resources like water, soil, air. These are valuable gifts to humankind from nature. Among these resources, the most important component is water (Postel, 1997). Soil, Air, Water, Biodiversity and human have a deep relationship with each other. Our environment is composed of the aforementioned abiotic components. When there is balance in nature then the best environment created as an approach to sustainable development. Imbalance in the environment affects the availability of water on earth. As we know that globally the quantity of water is 1.386 billion $m^3$. Approximately 3% of freshwater is present on earth and out of this freshwater only 0.3% is found in liquid form. Around 0.7% of 1.386 billion $m^3$ water is used for the domestic, Industrialization and agriculture purpose. Because of the increase in population, the demand for water is also increasing day by day which affects the availability of water sources and water quality. There is a decline in the water level and the sources of water. Details of various available sources of water on earth are given below:

**Table 1: Available sources of water on earth**

| Sr. No. | Sources of water | Total Water % |
|---|---|---|
| 1 | Ice Glaciers, Polar region | 69.56 |
| 2 | Groundwater | 30.10 |
| 3 | Lakes | 0.26 |
| 4 | Soil | 0.05 |
| 5 | Rivers | 0.006 |
| 6 | Environment | 0.04 |
| 7 | Biological and Metabolism | 0.003 |

**Source: (Shiklomanov and Rodda, 2003)**

**Table 2: Volume of Water resources on the Earth:**

| Sr. No. | Main sources of water | Volume in $Km^3$ |
|---|---|---|
| 1 | Total water resources | 1408.70 |
| 2 | Ocean Water | 1370.0 |
| 3 | Ice Glaciers, Polar region | 29.0 |
| 4 | Ground Water and soil moisture | 9.56 |
| 5 | Surface water, Rivers and lakes | 0. 14 |

**Source :( http.www.ied.edu.hk/esdwed/aids)**

**Table 3: Availability of water per person**

| Year | Population (in Lakhs) | Availability of water ($m^3$) per person per year |
|---|---|---|
| 1951 | 3610 | 5177 |
| 1991 | 8460 | 7209 |
| 2001 | 10270 | 1820 |
| 2025 | 13940 | 1341 |
| 2050 | 16400 | 1140 |

**Source: Govt. of India ministry of water resources (2009)**

**Table 4: Average Rainwater resources in India**

| | |
|---|---|
| Annual average rainwater | 4000 (billion $m^3$) |
| Annual average availability | 1869 |
| Usable Water resources | 1123 |
| Surface Water | 690 |
| Groundwater | 433 |

**Source (www.nih.rnetaclimatechangecentr.net)**

In India, the demand for water is increasing day by day because of the population explosion, which is a curse for humanity, but sources of water are limited. The demand of drinking water is increasing continuously with the population growth as there is exploitation of water sources and also it affects the quality of water. Due to urbanization and industrialization water sources are getting polluted and these are the major cause of water-borne diseases which is a concern of health perspective.

In future water, scarcity will become a serious problem because in the present scenario the sources of water like rivers and lakes are drying out. The demand for water is increasing in the agricultural sector for irrigation purpose and also the increasing uncertainty in monsoon leads to problems like drought and flood. From past 20-25 years, groundwater level has decreased and in India, it is a major concern for consideration as India is agriculture-based country and worldwide holds third position in major crop production. One of the major for this issue is the lack of awareness among the people. Interaction of the chemical and biological aspects has been discussed in the work of (Dugan, 1972). The requirement of water is more in urban area as compared to rural hence the water quality is chemically toxic in urban area toxic (Bandy, 1984).

**Impact of Water Pollution:**

There is loss 0.4 million lives due to scarcity and polluted water, unhygienic conditions and 0.52 million people died is due to the contribution of air pollution (WHO, 2007). In India environmental factors contribute to 60 years of ill-health per 1,000 population as compared to 54 in Russia, 37 in Brazil, and 34 in China. At the socio-economic level, the cost of water is extremely high. At the age of 5 years, 1.5 million children die each year due to water-borne diseases, 200 million person-days of work are lost each year, and the country loses about Rs 366 billion each year due to water-related diseases (Parikh 2004). About 90 million rupees have been lost in the treatment and production processes of water which cost 6 billion rupees and aforesaid processing of water cause water-borne diseases (McKenzie and Ray, 2004).

There are various water-borne diseases in human due to biological toxicity summarized in the given table 5:

**Table 5: Waterborne diseases in human**

| Sr.No | Name of disease | Microorganisms | Symptoms |
|---|---|---|---|
| 1 | Cholera | *Vibrio cholera* | Vomiting, diarrhea, Dehydration |
| 2 | Typhoid | *Salmonella Typhi* | Vomiting, diarrhoea, Swelling in the intestine, Tiredness, High fever |
| 3 | Bacterial dysentery | *Shigella flexneri* | Diarrhoea |
| 4 | Botulism | *Clostridium botulinum* | Double vision, abdomen pain, fatigue, nausea, constipation |
| 5 | Hepatitis | *Hepatitis A & B virus* | Yellowish colour of skin, Fatty liver, Stomach pain |
| 6 | Amoebiasis | *Entamoeba histolytica* | Diarrhoea with stomach pain |

Now the question arises how to solve the scarcity of water? There are different types of technique in agriculture like conservation agriculture techniques. In conservation agriculture, we use the sprinkler irrigation method so that less water is used and the drip irrigation method is also very useful in the agricultural area. These both techniques are used in many places in India. There is also a need for the management of water sources in the urban and rural area. Rainwater harvesting system is also beneficial in the water scarcity area like Rajasthan in India.

## Conclusion

This is the moral duty of everyone to conserve the water sources and its quality for sustainable development. Our generation is facing the problem of water scarcity, if we start making efforts for conservation of water sources the next generation might be saved from the same. Hence there should be the sanitation and awareness programs organized by NGOs, Private and Government sectors from time to time. We can organize different types of programmers which are given:

- Plantation on barren land.
- Plantation in Urban and rural areas.
- To provide the forest necessary to the rural people and its management.
- Renovation and sanitation of the drinking water resources.
- To control the leakage from the pipes of the drinking water supply.
- There should not be any dumping site near water supply sources.
- Regular testing of drinking water in water labs.

- There should be regular checking of water supply pipes to avoid the contamination of drinking water.
- There should be minimum wastage of water and reuse of water in washroom and tap water.

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# Zero-Valent Iron Nanoparticles for the remediation of water contaminants: A Mini-Review

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## Abstract:

Industrialization and urbanization lead to the contamination of groundwater and surface water to a large extent. Zero-valent iron nanoparticle (nZVI) is a promising material for water contaminants remediation due to its large surface area to volume ratio coupled with greater reactivity. The nZVI particles show high degradation potential towards chlorinated organic compounds, nitroaromatic compounds, heavy metals, nitrates, phosphates, dyes, etc. But these nanoparticles also exhibit small toxicity towards microorganisms. This mini-review highlights the properties and application of nZVI particles for environmental remediation and its toxicity towards microorganisms.

## 1. Introduction

Water contamination is one of the major environmental problems faced by the world which is drastically influenced by population stress and industrialization. Every year thousands of people are dying or diseased by consuming the contaminated water. Over the last few decades, nanotechnology was trying to replace conventional water contamination remediation techniques such as carbon adsorption, air stripping, oxidation through ozonation or chlorination, ultrafiltration and sedimentation. The specific properties of nanomaterials give a wide variety of opportunities for purifying contaminated water and providing clean water at low cost. The application of nanoparticles has now been extended to groundwater pollution remediation and soil pollution remediation too. Different nanomaterials like carbon nanotubes, nano filters, nanoscale zero-valent metals, nanomembranes etc., are being used for the remediation of water contamination. Among these, nanoscale zero-valent iron (nZVI) particles have a remarkable position due to its low cost, environmental compatibility and high reactivity.

## 2. Zero Valent Iron Nanoparticles

Iron metal considered as a most appropriate solution as permeable reaction barrier in groundwater pollution in the last few decades. The reactivity of metallic iron extremely increased when it changes to nano zero-valent iron (nZVI) particles.

High surface area, high reactivity, fast kinetics, small particle size, and magnetic property are the advantages of nZVI particles. The nZVI have a high potential for organic and inorganic contaminants degradation as it has a large number of reactive sites on its surface which is available for contaminant degradation and it leads to the reduction of the reaction time. They show high efficiency for removing chlorinated hydrocarbons, heavy metals, dyes, nitrates, phosphates, pesticides etc. Reduction, adsorption into the nZVI or iron oxide shell and precipitation are the mechanisms behind the activity of nZVI (Crane et. al, 2012).

In the laboratory, nZVI is synthesized by chemical and physical methods. Physical methods include inert gas condensation, high-energy ball milling and ultrasound shot peening etc. The chemical methods are reverse micelle synthesis, controlled chemical coprecipitation, chemical vapour condensation, pulse electrodeposition, liquid flame spray, liquid-phase reduction and gas-phase reduction etc. Core-shell structure, specific surface area and magnetic properties are the factors influencing the properties of nZVI particles. The nZVI nanoparticles typically show a core-shell structure with inner zero-valent iron core and outer iron oxide shell. Due to its high specific surface area and small size, the nZVI particles are highly reactive towards air and water. This leads to the oxidation of $Fe^0$ core. The core is to act as an electron source for the reduction of pollutants and iron oxides can absorb the degraded pollutants. The key disadvantages of nZVI are its tendency for agglomeration and oxidation (Li et.al, 2006). To make the nZVI particles as an efficient remediating agent, it could be modified or combined with different methods. Mostly these methods are Immobilization of nZVI onto supports like zeolite, polymers, etc., doping of nZVI with other metals like Ni, Cu etc. and combine nZVI with other techniques like sonication.

## 3. Remediation of environmental pollutants using nZVI particles

Since the last twenty years, nZVI particles is one of the most widely studied nanomaterials for remediation of water contaminants. The nZVI particles are used for the remediation of chlorinated hydrocarbons, pesticides, antibiotics, organophosphates, organic dyes, explosive compounds, heavy metals, nitrate, phosphate and perchlorate. Depending on the type of contaminant for the remediation, the pathways of the mechanism of nZVI particles are changed. The most possible approaches following nZVI particles mediated remediation arereduction, sorption, complexation, and co-precipitation. nZVI particles are useful for the degradation of chlorinated organic compounds (COCs) like trichloroethylene (TCE), carbon tetrachloride, 2,4-dichlorophenol, chlorothalonil, vinyl chloride, etc. COCs are degraded through reductive dehalogenation by using the nZVI particles as electron donor from the iron surface. In the case of TCE removal, the major final products after degradation are ethane and butane.

The nZVI particles effectively degrade nitroaromatic compounds from wastewater. In nitroaromatic compounds, the nitro groups are reduced into aromatic amine compounds by using nZVI particles, for example, nitrobenzene was reduced into aniline (Li et.al, 2006; Wei et. Al, 2019).

Since the last decade, nZVI particles show excellent removal efficiency for heavy metals including arsenic, mercury, cadmium, chromium, nickel, lead, copper and zinc from wastewater. They exhibit different removal pathways for the remediation of heavy metals. In the case of chromium, toxic Cr (IV) converts into Cr (III) by using nZVI particles as a reducing agent and it is immobilized into iron oxide surface through precipitation. Adsorption, reduction, surface precipitation and co-precipitation with various iron corrosion products such as ferrous/ferric oxide or hydroxide are the mechanism behind the removal of arsenic by using nZVI particles. Hg(II) was converted to Hg(0) via chemical reduction and Zn (II) was sequestrated by sorption to the iron oxide shell followed by zinc hydroxide precipitation. Co (II) removal was associated with the speciation of surface oxohydroxyl groups on the nZVI particles. Ni (II) and Pb(II) are removed by sorption with partial chemical reduction. Cu(II) was removed by reductive precipitation and Cd(II) removal pathway by nZVI was sorption and surface complexation (Crane et. al, 2012).

Nowadays nZVI particles are intensively investigated for nitrate and phosphate removal from the wastewater. The major phosphate removal mechanisms by nZVI particles are electrostatic adsorption, surface complexation and precipitation. In nitrate removal, nitrate has been reduced into $NH_3$, $N_2$ and $NH_4^+$ by oxidizing nZVI into $Fe^{2+}$, $Fe^{3+}$, $Fe_2O_3$, or $Fe_3O_4$ depending on the reaction conditions (Fua et al, 2014).

When the nZVI particles are reacted with water, the hydroxyl and hydrogen ions are generated by reducing $Fe^0$ to $Fe^{2+}$ and $Fe^{3+}$ ions. This reactive species will breakdown the chromophore group of the dye molecule. Since the nZVI particles are excellent electron donors and the dye molecules are good electron acceptors, the nZVI particles will also disrupt the auxo chrome group to decolorize the dye molecules. Even though the complete mineralization of dye molecule would be confirmed through total organic carbon (TOC) removal, only a few researchers are studied about TOC removal in the presence of bare nZVI particles and this shows only 20.3% to 55% TOC removal on dye decolorization. The intermediates and final products such as 1-diazo-2-naphthol, 2-naphthol, benzenesulfonate, sulfonic acid, and aromatic amines were presented in water after dye decolorization. This shows that only partial mineralization of the dye molecules was attained in the presence of bare nZVI particles.

By integrating other treatment techniques such as microwave radiation, ultrasonic irradiation, $H_2O_2$ oxidation, and UV irradiation with nZVI nanoparticles and by stabilizing nZVI particles with supports such as resin, catalytic metal, biopolymer, bamboo, persulfate, cellulose, biochar, graphene, etc., the nZVI particles can enhance the performance and reduce toxic by-products during textile dye degradation (Raman et al, 2016).

## 4. Toxicity of Zero Valent Iron Nanoparticles

The toxicity studies of nZVI particles are less compared to the other metal nanoparticles. In the available toxicity studies, they are mainly focused on microorganisms rather than plants, animals and mammalian cells. The high reactivity of nanoparticles and the generation of reactive oxygen species during reaction with water are the main reasons behind the toxicity of nZVI. When the nZVI isadsorbing to the cell membrane, it penetrates through the membrane and disturbs the functioning of the cell and the highly reactive oxygen species accumulate on cell environment and damage intracellular structure which leads to the death of the cell. The studies also show that surface modification of nZVI reduces the toxicity of nanoparticles (Chen et al, 2017).

## 5. Conclusion

Several nanomaterials have been used for water contaminant remediation with the aim of cleaner technology at low cost. In that nZVI particles attained a remarkable position due to its unique properties and environmental compatibility. These nanoparticles exhibit high removal efficiency for several types of water pollutants. Reduction, sorption, complexation, and co-precipitation are the main pathways of mechanism for the degradation of these pollutants. Further studies are needed for the stabilization of nZVI particles and their toxicity towards the living organisms.

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# Water Pollution

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Water is essential for all forms of life and none can survive on this earth without water. The surface of earth measures 50,000 billion hectares of which about 70% is covered by water and the rest is land. The total volume of water on the earth is 1011 million cubic kilometers of which about 97% i.e. 986 million cubic kilometers is contained in oceans and an additional 3 million cubic kilometers, of salty water is buried underground and the remaining 2.5% accounts for the total fresh water, frozen water of glaciers and polar ice caps. Chemically, water contains two parts of hydrogen and one part of oxygen.

There is a great concern for rapidly deteriorating quality of water. The causes of water pollution are many but urbanization; industrialization and increasing pollution are more prominent among them. Water is said to be polluted when its quality or composition is changed either naturally or as a result of human activities and it becomes unsuitable for drinking and less suitable for domestic, agricultural, industrial, recreational and other uses.

India being a vast country with an area of about 806 million acres, the rain fall constitutes one of the most important and largest sources of water. The original river water is very pure, but it takes up suspended impurities as it flows through the plains. In this process, it also dissolves CO2 from the atmosphere, which enables water to dissolve carbonates as it passes over the river beds .

Waste-water is the combination of liquid or water-carried wastes originated from the sanitary conveniences of dwellings, commercial or industrial facilities and institutions, in addition to any ground water, surface water and storm water that may be present. Untreated wastewater generally contains high levels of organic material, numerous pathogenic microorganisms, as well as nutrients and toxic compounds. It thus entails environmental and health hazards and, consequently, must immediately be conveyed away from its generation sources and treated appropriately before final disposal. The ultimate goal of wastewater management is the protection of the environment in a manner commensurate with public health and socioeconomic concerns. Wastewater treatment is becoming even more critical due to diminishing water resources, increasing wastewater disposal costs.

The municipal sector consumes significant volumes of water, and consequently generates considerable amounts of wastewater discharge.

Duckweed to Remove water Pollution:

Duckweed are aquatic plants are the world's smallest and simplest flowering plants. Duckweeds are floating plants that grow on the surface of still or slow moving waters during warmer weather. Because duckweeds usually reproduce by budding, they can multiply very quickly and covers the entire surface of a pond in a short amount of time. Small numbers of duckweeds will not harm a pond, but large numbers will block sunlight from entering the pond and upset the pond's oxygen balance, placing the fish population in danger.

The lemna sp. are the most common duckweeds. Lemna grow up to 4 mm (5/32 inch) wide and have a single root dangling from the " leaf of the plant. Duckweeeds do not have true leaves or stems: they look like grains of green meal floating on the water surface. They are generally less than 1mm (1/32 in ) wide and barely visible as individuals. This type of duckweed does not have roots.

Duckweed species are small floating aquatic plants found worldwide and often seen growing in thick, blanket-like mats on still or slow moving, nutrient-rich fresh or brackish waters.

Duckweed-Based Wastewater Treatment systems

The basic concept of a duckweed wastewater treatment system is to farm local duckweeds on the wastewater which needs to be treated. The rapidly growing plants act as a nutrient sink, absorbing primarily nitrogen, phosphorus, calcium, sodium, potassium, magnesium, carbon and chloride from the wastewater. These ions are then removed permanently from the effluent stream following the harvesting of a proportion of the crop. Depending on the wastewater, the harvested crop may serve as: (i) an animal feed; (ii) feed supplement supplying protein and minerals; or (iii) fertiliser. However, it may have to be decontaminated prior to feeding to animals if heavy metals are present in the water as these are concentrated by the duckweed.

# Voice of Environment Recent Initiatives

**Clean Green and Eco-friendly Assam vision for plastic free environment initiative by Voice of Environment**

The Voice of Environment is working for **Clean Green and Eco-Friendly Assam** vision from long time and has been conducting various campaigns in school, community and also working in various initiatives for iconic and heritage places for state of Assam. **Voices of Environment (Youth Environmental Organization)** in association with **MyGov Assam** have conducted an awareness program to build mass sensitization among the citizens to **beat single use plastic** and cleanliness aspect on **20th October 2019 (Sunday**). The team has selected one iconic place of state as the **Basistha Temple** area where VoE is already working and more two numbers of villages as **Bonda** and **Panikheti** area of **Kamrup Metropolitan District** of Assam. During the drive at Basistha Temple the **Doloi (Head Priest) Girindra Mohan Sarma** said this is very nice initiative and also ask to all the local youths, devotees and visitors to come forward for the cause so that Basistha temple can be a **plastic free clean and eco friendly premise**. He also praised the initiative by team VoE which is working for the cause from long time **Doloi** also supported this mission by **Government of Assam** on **cleanliness and beat single use plastic**.

During this campaign and the drive team lead by **Bhaskar Hazarika, Jugal Krishna Medhi** and **Environmentalist Moharana Choudhury** together started the awareness program with local people and villagers where they have handed over the **bamboo** made bins and **Volleyball** sets to local **youth clubs** which were identified earlier for motivating, building and creating awareness among the local people for cleanliness and beat single use plastic items as concept of connecting the youths with sports to keep clean their localities along with their game as **sports** has always been an easy medium to attract the youths and also it can be used to bring a change. The team VoE members also interacted with local youths and residents regarding the cleanliness aspect and negative impacts of plastic pollution to environment especially single use plastic as these are generally been thrown here and there without proper disposal and recycle. **Bamboo bins** which were distributed during the campaign will help the plastic wastes to send for recycling process so that it can't pollute our environment and the areas, localities and villages will remain clean. During the campaign large number of youths, local residents and villagers were participated the event with great enthusiasm.


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WARNER'S TON HELPS AUSTRALIA HAMMER SRI LANKA 11

TODAY'S HAPPY TIMES Q1.Who won the 1st Australia-Sri Lanka T20I held yesterday? READ Q2.Who did Tottenham play in the Premier League on Sunday? WIN

# Renewed demand for bamboo bins give craftsmen a glimmer of hope

Kangkan Kalita | TNN

Guwahati: Bamboo craftsmen in rural Assam are seeing a silver lining with Swacch Bharat Abhiyan, as part of which bins made of bamboo are being installed in some iconic tourist locations of Guwahati for disposing of solid wastes.

Assam, despite producing abundant varieties bamboo, craftsmen from rural areas of the state are struggling to find a viable market for their products. But, the Swacch Bharat Abhiyan, being carried out in collaboration between MyGovAssam social media campaign and Voices of Environment (Youth Environmental Organisation) NGO, has brought the bamboo bins to the limelight in the city for being an inexpensive alternative for disposing waste, especially unusable plastics.



MOBILE INITIATIVE

After successful installation of the bamboo bins in the historic Basistha temple in the city, the next targets under the joint initiative is to fit these eco friendly bins in the Kamakhya temple and Umananda temple premises — two most popular tourist destinations in Guwahati. This has ushered in a ray of home for bamboo craftsmen involved in manufacturing the bamboo products, who had been struggling to make ends meet due to lack of business avenues.

"As we go about implementing the Swacch Bharat Abhiyan, the endeavour is to get rid of plastic, which becomes a burden on the environment. As the cleanliness campaign is being launched on a massive scale pan-India and in Assam, it infuses positive vibes if we can fight this battle against dirt with eco-friendly materials. Bamboo bins will decompose in earth, unlike plastic bins. We must keep this in mind as garbage disposal bins are being procured by various government and private agencies on a large scale. That's why choosing bamboo for the task was a wise decision," said Simanta Sarma, the entrepreneur supplying bamboo bins for the project.

Besides covering the Basistha temple, two other rural locations in Kamrup (Metropolitan) district — Bonda and Panikhaiti — have seen installation of bamboo bins under the joint initiative.

A group of 18 craftsmen have produced the bamboo bins at Patacharkuchi in Barpeta district, for whom the Swacch Bharat Abhiyan is not just a campaign, but, has emerged as a way for earning livelihood. At a time when the tea garden workers in the state are staging agitations to get Rs 350 daily wage, the bamboo craftsmen are also getting this amount from the government-sponsored drive since the launch of the mission Clean Green and Beat Plastic Pollution campaign by the Assam government which was formally inaugurated by chief minister Sarbananda Sonowal in Guwahati on October 1.

"Bamboo bins which are being distributed during the campaign will help gather plastic waste that can then be sent for recycling, so that these can't pollute our environment, and the areas, localities and villages remain clean. During the campaign, a large number of youth, local residents, and villagers are participating with great enthusiasm," said environmentalist Moharana Choudhury of Voices of Environment, who is leading the campaign with fellow team members Bhaskar Hazarika, Jugal Kumar Me

TELEVISION

# Plastic-free vision for Assam

**GUWAHATI, Oct 22:** As per the mission Clean Green and Beat Plastic Pollution campaign by Government of Assam, which was formally inaugurated by Chief Minister of Assam Sarbananda Sonowal at Guwahati Volleyball Training Centre at Judges Field recently, as Clean, Green and Fit Village campaign.

Voices of Environment (Youth Environmental Organisation) in Association with MyGovAssam, conducted an awareness program to build mass sensitization among the citizens for beat single use plastic and cleanliness aspect on Sunday. The team has selected one iconic place of state as the Basistha Temple area where VoE is already working and two more villages, Bonda and Panikheti area of Kamrup Metropolitan District of Assam.

# RPF constable, another arrested for child abduction

STAFF REPORTER

**GUWAHATI, Oct 22:** A missing complaint was registered at Government Railway Police (GRP) station on Sunday by a woman identified as Gunja Devi. According to Devi, her 1.5 year old daughter and her husband, Sushil Prasad, were missing since the past one and a half month.

Gunja Devi was from Dibrugarh and Sushil Prasad from Shillong, however