International Journal of Engineering& Scientific Research
Vol.11 Issue 03, March 2023
ISSN: 2347-6532 Impact Factor: 6.660
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Water pollution – A study of effects and sources

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Abstract

Water is considered to a very important resource which is renewable in nature and is essential for sustaining different forms of life, well-being, economic development and food production. Water cannot be substituted by any form of liquid as there are many uses of water. There are different uses of water like for washing clothes, drinking, gardening, bathing, swimming etc. Water is used by every living being and no other type of liquid could replace water as other liquid forms like milk, and other items are having limited uses. It is not possible to de-pollute water easily and it becomes bit expensive for transporting water for removing the dirt in water and making it usable. Water is considered to be gift towards mankind because of its nature. There are different capabilities of water like diversion, recycling, storage and transport. There are many rivers in India and their tributaries. Some of these rivers are said to be perennial in nature and few might be seasonal. It becomes bit challenging to actually manage water quality better. These challenges could be temporal and spatial variation in surface water resources which are distributed unevenly and in a similar manner variation in rainfall. Sometimes ground water is at times overused and contaminated, drainage and salinization and non-maintenance of water quality. The waste water is not reused many a times or used in a partial manner. Waste water generally from urban settlements remains untreated. The runoff from irrigation sector, mis-management of solid wastes from municipal and even animal dung in rural areas. There are different parts in the country, where water comes from domestic resources and it becomes difficult to treat them in a proper way as there is lack in sanitation facilities. Waste water which contains a lot of organic pollutants, find their way in the ground and the surface water near human habitations and this creates a place from where the human being could draw water for using it further.

Keywords: renewable, habitation, contamination, economic development

1. Introduction

Water is considered to a very important resource which is renewable in nature and is essential for sustaining different forms of life, well-being, economic development and food production. Water cannot be substituted by any form of liquid as there are many uses of water. There are different uses of water like for washing clothes, drinking, gardening, bathing, swimming etc. It would become difficult to transport water from one place to another, or even the cost of recycling, diversion etc. is much. Water is the most usable natural resource among different forms of natural resources. The ground water and surface water resource of our country playsa very important role innavigation, livestock production, hydropower generation,agriculture, fisheries, recreational activities, forestry, industrial activities etc. Fresh water ecosystem of world comprisesof around 0.5% of earth's surface and having volume of 2.84x105 Km. The rivers mainly constitute insignificant amount (0.1%) of land surface. Only 0.01% of waters of earth occur in the river channels. They are having lower quantities, the running wateris having enormous significance (Wetzel, 2001). India receivedan annual precipitation which is around 4000 km which also includes snowfall. Out of them, monsoon rainfall can be said to have an order of 3000 km. In India, rainfall is dependent on north-eats and south-west monsoons, local storms, shallow cyclonic depression and other such disturbances(Kumar *et. al*., 2005). This would mostly take place having an influence of the south-west monsoon between the months of June and September, this is applicable in different parts of the country except Tamil Nadu, where it can be seen having an influence of north-east monsoon during the months of October and November (Kumar *et. al*., 2005). Indiais gifted with the river system which comprises of many rivers having many tributaries. The rivers are said to be perennial in nature and some are seasonal. India occupied 3.29 million km as per geographical area, which constitutes 2.4% of land area in the world, this would support more than 15% of population of the world. In India population on 1stMarch 2001 has been 1,027,015,247 people. India has been supported by1/6thworld's population, 1/50thof world's land and 1/25thof various forms of water resources in the entire world. (Water Management Forum, 2003).

During last few decades, the demand for fresh water has increased a lot because of rapid growth in the population and this resulted in demand for fresh water. The demand for fresh water increased since there was huge population explosion and also since there was a tremendous growth in industrialization (Ramakrishnaiah*et al*., 2009). Human health is

being threatened by mostly agricultural activities which are performed for development and this has relation with fertilizers being applied excessively and also the unsanitary conditions (Okeke and Igboanua, 2003). Anthropogenic activities which are related to agricultural practices, population expansion, industrialization and extensive urbanization and has led to a good quality of water which has been deteriorated in different parts of the world (Baig*et al*. 2009, Mian*et al*., 2010, Wang *et al*., 2010). Additionally, deficiency in water resources has increasingly restrained controlling of water pollution and improvement in water quality(Bu *et al*., 2010). Water pollution is being focused of research for the scientists and government. Hence, protection of quality of the river water has become extremely urgent since there is serious pollution of water and water is considered to be scarce in the entire globe.

2. Sources of water pollution:

Water pollution can actually occur from two main sources i.e. Point source and Non-point source Point sources based on pollution are considered to be those that are having direct identifiable sources. An example of point source are pipes attached to different factories, oil spills from tanker, effluents which come out from various industries. Point source of pollution includes wastewater effluents (both industrial and municipal) and storm sewer discharges and affect mainly the area which is quite near. There are few non-point source of pollution also and they are said to be the ones which arise from various sources of origin and their main source cannot be determined. This happens when there is water pollution and it is getting polluted due to various reasons. Water gets contaminated as contaminants enter into the surface or groundwater and arrives in environment from various sources, some of which cannot be identified. Different examples are runoff from urban waste, agricultural fields etc. Sometimes pollution gets entered into environment through a particular source and this effects hundreds or thousands of people and other living organisms which are miles away. Such a pollution can be referred to as trans-boundary pollution. An example of one such pollution is radioactive waste which travels through oceans from nuclear reprocessing of plants to the nearby countries. The water pollutants could be organic and inorganic water pollutants.

1. Organic water pollutants – These pollutants comprise of herbicides, insecticides, organohalides and various other chemical forms; bacteria from sewerage and livestock farming; processing of food wastes; pathogens; organic compounds which are volatile etc.

2. Inorganic water pollutants–These pollutants mainly arise from various heavy metals which come from acid mine drainages; silt from the surface run-off, slash, burning practices, logging, land filling, fertilizers from various agricultural run-off that include phosphates and nitrates etc. and various forms of chemical waste which come from different industrial effluents.

Table 1. The table below indicates different characteristics of point as well as nonpoint source of chemical inputs for receiving waters (Carpenter *et al*., 1998).

Point Sources	**Nonpoint Sources**
- Wastewater effluent (industrial and municipal) - Leachate andrunoff from waste disposal site - Infiltration and runoff from animal feedlot - Runoff from oil fields, mines, unsewered industrial site - Storm sewer outfall from various cities with population >100,000 -Overflow of combined sanitary and storm sewers - Runoff from various construction sites >2 ha	- Run-off from the agriculture (includes return flow from the irrigated agriculture) - Runoff from range and pasture - Urban runoff from sewered and unsewered areas having population <100,000 - Septic tanks leachate and run-off from the failed septic tank systems - Runoff from various abandoned mines - Runoff from various construction sites - Atmospheric deposition over water surface - Activities based on land which generate contaminants like wetland conversion, logging, development and construction of waterways or land

Some important sources of water pollution have been discussed below:

- **Urbanization:** Urbanization leads to a higher concentration of phosphorus in the urban catchments (Paul and Meyer, 2001). Increase in imperviousness, increase in runoff from the urbanized surfaces, industrial discharges and increased municipal, this would result in increase in loadings of the nutrients to the urban streams. This would make urbanization seconds only to the agriculture as major cause of the stream impairment.
- **Sewage and other Oxygen Demanding Wastes:** Solid waste management has not been successful since there have been a huge volume of non- biodegradable wastes and organic waste which is generated daily.This would lead to garbage in many

parts of India and it is disposedunscientifically and it would ultimately lead to an increase in the load of pollutants in ground water and surface water course. Sewage could be a fertilizer since it would release an important nutrient to environment like phosphorus and nitrogen which animals and plants need them for growth. Chemical fertilizers are being used by the farmers add nutrients in soil, which would get drained into the seas and rivers and they add to fertilizing effect of sewage. Together, fertilizers and sewage could cause massive increase in growth of plankton or algae which facilitates huge area of lakes, rivers or oceans which create a condition which is known as algal bloom and this reduces dissolved content of oxygen in water and this would kill different other living organisms like fish.

- **Industrial Wastes:** Many industries have been situated along river banks like steel and paper industry since they are having huge usage of water for their manufacturing processes and finally their waste contains alkaline, acid, dyes and various other chemicals which are dumped and poured into the river in the form of effluents. Chemical industries which are concerned with manufacturing of Aluminium, release a larger amount of fluorides through emissions into air and effluentsin the water bodies. The fertilizer industry generates huge ammonia whereas the steel plants generates cyanide. The chromium salt are being used in the industrial processes for production of the sodium dichromate and various other compounds which containchromium. All these discharges would be arrived finally at the water bodies in different forms of effluents which would affecthuman health and various living organisms.
- **Agro-chemical Wastes:** In agricultural sector, electricity and waterfor irrigation have been subsidized due to political reasons. This would lead towards wasteful flood irrigations rather than adopting more optimal practice like drip irrigation and sprinkler. Farming practices and cropping patterns also may not encourage judicious usage of water necessarily. There could be loss of water due to seepage and breaches which would result in salinity and water logging. Agro-chemical waste would include pesticides and fertilizers. The pesticides could be insecticides and herbicides which are widely made use in the crop fields for enhancing productivity. When pesticides are improperly disposed from different fields and the agricultural activities contribute pollutants in the soil and water bodies. Some pesticides are: Dieldrin,DDT, Malathion,Hexachloro Benzene, Aldrin etc. Pesticides then reach the water bodies through the surface run-off from the

agricultural fields, drift from spraying, direct spraying and dusting, washing down precipitation in the low lying areas which would pollute quality of water. Most of these are actually persistent and non-biodegradable in environment for a longer time period. Such chemicals might reach human through the food chain which led to bio-magnification.

- **Nutrient enrichment:** Source of nutrients in the surface water could be divided in a broader manner into anthropogenic and natural types. Contribution towards pollution by the natural source has been quite low due to the balance which has been established by natural system between consumption and production of nutrients over a particular period of time. Anthropogenic source of contaminants can be said to be the ones which get contributed from industrial wastes, domestic and agriculture wastes. Nutrient concentration in rivers and streams have a strong correlation with usage of land and also disturbance gradients. Contrast to the point source of nutrients which are relatively easier for being monitored, regulated, nonpoint source like crop fertilizers, livestock, temporal variability and urban runoff exhibits. Following stronger regulation of the point sourcesof inputs as in response to Clean Water Act, nutrients from the nonpoint sources are considered to be major source of pollution in water in United States (Carpenter *et al*., 1998).
- **Thermal pollution:** Change in water temperature would adversely affectaquatic biota and water quality. Majority of thermal pollution in the water is mainly caused from human activities. Some important sources related to thermal pollution are petroleum refineries,nuclear power, electric power plant, coal fire power plants, steel melting factory, and boilersfrom the industries that release larger heat to water bodies which results in changes in chemical, biological and physical characteristics of receiving the water bodies. High temperature would lead to declinein content of oxygen, disturbs respiratory and reproductive cycles, digestive and respiratory rates and various other physiological change which might cause difficulties for aquatic life.
- **Oil spillage:** Oil discharges into sea surface by way of leakage or accident from the cargo tankers which are carrying diesel, petrol and various other types of derivatives which pollute the sea water to great extent. Exploring oil from the offshore would also lead toward oil pollution in the water. Residual oil spread over water surface forms thin layer of the water-in-oil emulsion.

- **The disruption of sediments:** Construction of many dams for water reservoirs or hydroelectric power can result in reduction in flow of sedimentswhich affect adverse formation of increase in the coastal erosion, beaches and this would also lead to reduction in the nutrients flow from the rivers into various seas which would lead to potential reduction in stocks of coastal fish. Increase in the sediments flow could lead to problems. During a particular construction work, rock, soil and various other kind of fine powders would sometimes enter the nearby rivers in larger quantities, which causes water to become silted or muddy. These extra sedimentscould block gills of fish which could cause suffocation.
- **Acid rain pollution:** Water pollution which alters surrounding of plant's pH level, which is sometimes a result of acid rain, it could kill plants of harm them. Atmospheric nitrogen dioxide and sulfur dioxide which are emitted from human-made and natural sources like burning fossil fuel/ interact with various atmospheric chemicals, volcanic activity which would include oxygen and hydrogen for forming nitric acid and sulfuric in air. Such acids fell down to the earth in the form of snow or rain precipitation. Once the acid rain reachthe ground, it would flow into the waterways which would carry the acidic compounds into the water bodies. Acid rain generally gets collected in the aquatic environments and this would lower the pH level and would affect aquatic biota.
- **Radioactive waste:** Radioactive pollution is said to be caused by presence of the radioactive material in water. These are classified as smaller doses which would temporarily stimulate metabolism and larger doses that could damage the organismsand lead to genetic mutation. Sources might formed by radioactive sediment or water which is used in the nuclear atomic plants, nuclear power plant, exploitation of radioactive minerals, uses of various radioisotopes in the research and medical purposes.
- **Introduction of Alien species -** In certain parts of world, there are alien species which are known as invasive species which act as major problem causing water pollution. Outside the normal environment, there are no such natural predators, hence they spread rapidly and dominate plants or animals which thrive there. Some common examples of the alien species includes zebra mussels which are found in Great Lakes of USA, these are carried there from Europe through ballast water.

Mediterranean Sea is said to be invaded by a special kind of alien algae which is called *Caulerpataxifolia*.

- **Climate Change -** Global warming has created an impact on the water resources through an enhanced evaporation, frequency, duration, geographical changes related to precipitation intensity, soil moisture and even severity of floods and droughts. Future projection with the use of climate models have pointed out that monsoon rainfall could increase in few parts of the country, due to increase in sulphate aerosols and greenhouse gases. Relatively smaller climate changes could have a huge impact over water resources, mainly in semi-arid and the arid regions like North-West India. This could have an impact on drinking water, generation of hydroelectric power, and this would result in a limited supply of water and even land degradation. Apart from rains during monsoon, India makes use of perennial rivers that originated in Himalayan and Hindukush ranges and they depend on the melted water from glacial. Since there is coincidence of melting and summer monsoon seasons, any kind of intensification of monsoon could contribute towards flood disasters in Himalayan catchment. Rise in temperature would contribute to rise in snowline, and this would reduce capacity of various natural reservoirs and would increase risk of the flash floods during wet season. Increase in the temperature could lead towards increase in eutrophication in fresh water supply and wetlands. (CPCB Report, 2013).

3. Effects of water pollution:

There are different effects of polluted water on the aquatic and human life.

1. Effect of water pollution on human health

- **Chemicals in water could affect the health of humans:** There are some chemicals which affect human health are presence of different heavy metals like Arsenic, Cadmium, petrochemicals, Fluoride, chlorinated solvents,Mercury, Lead, nitrates and pesticides. Some of these chemicals are present in water and they are essential like Fluoride, but its presence could lead to weakening bones and dental carries. This could happen when Fluoride exists in bigger quantity in water. Another such chemical is Arsenic, which is said to be quite toxic in nature and this chemical reaches water in quite naturally or fromdifferent type of waste water of ceramic industry, tanneries, insecticides and chemical factories.

- **Water borne disease:** There are various micro-organisms that play an important role in micro-organisms and water quality which are concerned with the diseases which are water borne like *Shigella sp., Salmonella sp., Vibrio cholera and Escherichia coli*(Adetunde and Glover, 2010). All such lead to diarrhoea, dysentery, typhoid fever, cholera and gastroenteritis. Water pollution sometimes becomes quite dangerous when faeces enterswater supply. There are many such diseases which get perpetuated by faecal-oral transmission route where in pathogens get shed in the human faeces (Adetunde and Glover, 2010). When faecal*coliforms is present, E. coli could be used in the form of indicator for understanding the presence of such water* borne pathogen (Adetunde and Glover, 2010).

2. Effect of water pollution on plants

The following are the effects of water pollution on plants:

- **Effects of acid deposition**: Many gases which come from aerosols, acid and various other substances which are acidic in nature get released into atmosphere from domestic or industrial sources of combustion from the fossil fuels which would finally fell down to the ground and they reach different water bodies along with running rainwater from the soil surfaces which is polluted and cause acidification of various water bodies through lowering of pH.There are different countries, wherein there exists nitrates, chloride and sulphates and these have found in different water bodies like ponds, river and lakes.
- **Nutrient deficiency in the aquatic ecosystem**: Population of microorganisms which tend to decompose like fungi and bacteria decline in the water which is acidified which would reduce rate of decomposing organic matter which affects nutrients cycling. The level of pH which is very critical for aquatic species is said to be 6.0. There is diversity of different species and many of their pH declines whereas abundance and number of species which are said to be acid tolerant increase. Proliferation of the filamentous algaeforms thick mat at initial phase of acidification in water. Green algae anddiatoms disappear below the level of pH 5.8. *Cladophora*is said to be a specie which could tolerate high acid and it exists in abundance in the freshwater bodies which are quite acidic. Macrophytes do not exists in the acidic water since their roots generally get affected in water which results in poor growth in the plants.

- **Effects of the organic matter deposition**: The organic matter which comes from decaying and dead material of animals and plants get directly deposited from different sewage discharge and they get washed along rainwater into the water bodies which might cause an increase in microbes/ decomposers like anaerobic and aerobic bacteria. Organic matter gets decomposed and this would lead to increase in the level of nutrients which are available in the water level which would favourluxuriant growth of blue-green and planktonic greenalgal bloom. Additionally many macrophytessuch as *Eicchhornia*, *Salvinia*, *Azolla*, etc. are growing rapidly which has caused reduction in the penetration of light into the deepr layer of the water body which declines in submerged flora.
- **Effect of detergent deposition**: There are different detergents which come from the usage of water for industrial and domestic purpose which gets washed into different water bodies and causes serious effect on the plants. These detergents could contain a higher amount of phosphates that results in enrichment of phosphate in water. Phosphate enters plants through the surface or root absorption which causes retarded growth in plants, elongation in the roots, fixation of carbon dioxide, photosynthesis, pollen germination, also growth in the pollen tubes, destructs chlorophylls as well as cell membranes.
- **Effect of agricultural chemicals**: There are different agricultural chemicals which come from herbicides, pesticides, fertilizers, insecticides etc. which are applied to the crops in more quantity gets washed away with the rainwater as the runoff, enters into soil and it would finally get arrive at water bodies. Utilization of different chemicals from the fertilizers results in the eutrophication through enrichments of various nutrients. Ammonium from different fertilizers can be said to be acidic by nature and they cause acidification in water.
- **Effects of industrial wastes**: Effluents from different industries would contain inorganic as well as organic waste product. Any kind of fly ash would form a thick cover that would floatover water and this would reduce penetration of any kind of light deep into water bodies. This ash would increase alkalinity in water and would cause any kind of reduction in essential base which might lead to death among aquatic plants. Liquid form of organic effluent would change the availability of pH level in water and specific toxicity effect on aquatic plants would vary which would depend on chemical composition. There might be additive, antagonistic and

synergistic interaction between different metals when their effect is tested on the plants and these effects would be reduced in the buffered and hard freshwater bodies.

4. Control of Water Pollution

There are different key challenges for better management of quality of water in India which would comprise of water quality which comprise of spatial and temporal variation in rainfall, geographic distribution wherein surface water resource has considered to be uneven, over usage and contamination of ground water, salinization and drainage, water quality problem which is due to its treatment, untreated and partially treated wastewater from different urban settlements, run-off from the irrigation sector, industrial establishments, poor management of solid waste from the industrial areas and animal dung in the rural areas (CPCB Report, 2013). Some control measures are mentioned below:

1. Some plans have been initiated to address trapping, treatment and diversion of municipal wastewater i.e. National River Action Plan and Ganga Action Plan.

2. In many parts of country, wastewater from different domestic sources can be hardly treated with the effect of sanitation facilities which are inadequate. Waste water which could containpollutant load which is highly organic, find their way into groundwater and surface water course near vicinity of habitation of human being from where water could be drawn for usage.

3. With rapid urbanization and industrialization, water requirement for industrial and energy use can be estimated for rising towards around 18 percent of total requirements in the year 2025 (CPCB Report, 2013). Poor environment management system, especially in the industries like thermal power station, metals, minerals, chemicals, sugar mills, leather processing which qould led to discharge of organic wastewater and highly toxic wastewater.

4. For agricultural sector, electricity and water for irrigation is provided at a subsidized rate due to political reasons. This would lead to flood irrigation which is wasteful instead of adopting more optimal practice like drip irrigation and sprinklers. Farming practices, cropping patterns and optimized irrigation need to be encouraged for using water judiciously.

5. There needs to be ban on clothes being washed and laundry at river bank.

6. Industries need to be install Effluent Treatment Plant (ETP) for controlling pollution from the source itself.

7. All cities and towns should have Sewage Treatment Plants (STPs) which could clean sewage effluents.

8. Pesticides, herbicides and fertilizers are being used in an improper way in farming and it is necessary that they should organic methods for farming instead of using such harmful items for farming. Cropping practice in the riparian zone need to be banned for protecting riparian vegetation which grows there.

9. Harvesting of rain water should be practiced for prevention of depletion of the water table.

10. People should be made aware about problems which are being faced due to water pollution and this would help them in preventing any kind of water pollution. There should be education and awareness programmes so that the people could understand how important is water and also about different prevention of pollution measures.

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