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WATER POLLUTION-SOURCES,EFFECTS AND CONTROL

M. Romeo Singh[1*] and Asha Gupta[2]

[1*] *Centre for Biodiversity, Department of Botany*
Nagaland University, Lumami-798627, India
[2]*Centre of Advance Study in Life Sciences, Department of Life Sciences, Manipur University, Canchipur-795003, Imphal (India)*

Introduction

Water is one of the renewable resources essential for sustaining all forms of life, food production, economic development, and for general well being. It is impossible to substitute for most of its uses, difficult to de pollute, expensive to transport, and it is truly a unique gift to mankind from nature. Water is also one of the most manageable natural resources as it is capable of diversion, transport, storage, and recycling. All these properties impart to water its great utility for human beings. The surface water and groundwater resources of the country play a major role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, recreational activities etc. The freshwater ecosystems of the world comprise only about 0.5% of the earth's surface and have a volume of 2.84x105 Km^3. Rivers constitute an insignificant amount (0.1%) of the land surface. Only 0.01% of the waters of the earth occur in river channels. Inspite of these low quantities, running waters are of enormous significance (Wetzel, 2001). India receives annual precipitation of about 4000 km^3, including snowfall. Out of this, monsoon rainfall is of the order of 3000 km^3. Rainfall in India is dependent on the south-west and north-east monsoons, on shallow cyclonic depressions and disturbances and on local storms (Kumar *et. al*., 2005). Most of it takes place under the influence of south-west monsoon between June and September except in Tamil Nadu, where it is under the influence of north-east monsoon during October and November (Kumar *et. al*., 2005). India is gifted with river system comprising more than 20 major rivers with several tributaries. Many of these rivers are perennial and some of them are seasonal. Although India occupies only 3.29 million km^2 geographical area, constituting 2.4% of the world's land area, it supports over 15% of the world's population. The population of India as on 1st March 2001 stood at 1,027,015,247

persons. Thus, India supports about 1/6th of world population, 1/50th of world's land and 1/25th of world's water resources (Water Management Forum, 2003).

In the last few decades, there has been a tremendous increase in the demand for freshwater due to rapid growth of population and the accelerated pace of industrialization (Ramakrishnaiah *et al*., 2009). Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions (Okeke and Igboanua, 2003). Anthropogenic activities related to extensive urbanization, agricultural practices, industrialization, and population expansion have led to water quality deterioration in many parts of the world (Baig *et al*. 2009, Mian *et al*., 2010, Wang *et al*., 2010). In addition, deficient water resources have increasingly restrained water pollution control and water quality improvement (Bu *et al*., 2010). Water pollution has been a research focus for government and scientists. Therefore, protecting river water quality is extremely urgent because of serious water pollution and global scarcity of water resources.

Sources of water pollution:

Water pollution can occur from two sources. 1. Point source and 2. Non-point source (**Table 1**). Point sources of pollution are those which have direct identifiable source. Example includes pipe attached to a factory, oil spill from a tanker, effluents coming out from industries. Point sources of pollution include wastewater effluent (both municipal and industrial) and storm sewer discharge and affect mostly the area near it. Whereas non-point sources of pollution are those which arrive from different sources of origin and number of ways by which contaminants enter into groundwater or surface water and arrive in the environment from different non identifiable sources. Examples are runoff from agricultural fields, urban waste etc. Sometimes pollution that enters the environment in one place has an effect hundreds or even thousands of miles away. This is known as transboundary pollution. One example is the radioactive waste that travels through the oceans from nuclear reprocessing plants to nearby countries. Water pollutants may be i)Organic and ii)Inorganic water pollutant.

1. Organic water pollutants: They comprise of insecticides and herbicides, organohalides and other forms of chemicals; bacteria from sewage and livestocks farming; food processing wastes; pathogens; volatile organic compounds etc.
2. Inorganic water pollutants: They may arise from heavy metals from acid mine drainage; silt from surface run-off, logging, slash and burning practices and land filling; fertilizers from agricultural run-off which include nitrates and phosphates etc. and chemical waste from industrial effluents.

Table 1. Characteristics of point and nonpoint sources of chemical inputs to receiving waters (adapted from Carpenter *et al*., 1998).

Point Sources	**Nonpoint Sources**
- Wastewater effluent (municipal and industrial) - Runoff and leachate from waste disposal sites - Runoff and infiltration from animal feedlots - Runoff from mines, oil fields, unsewered industrial sites - Storm sewer outfalls from cities with a population >100,000 -Overflows of combined storm and sanitary sewers - Runoff from construction sites >2 ha	- Runoff from agriculture (including return flow from irrigated agriculture) - Runoff from pasture and range - Urban runoff unsewered and sewered areas with a population <100,000 - Septic tank leachate and runoff from failed septic systems - Runoff from construction sites - Runoff from abandoned mines - Atmospheric deposition over a water surface - Activities on land that generate contaminants, such as logging, wetland conversion, construction, and development of land or waterways

Some of the important sources of water pollution are discussed below:

Urbanization: Urbanization generally leads to higher phosphorus concentrations in urban catchments (Paul and Meyer, 2001). Increasing imperviousness, increased runoff from urbanized surfaces, and increased municipal and industrial discharges all result in increased loadings of nutrients to urban streams. This makes urbanization second only to agriculture as the major cause of stream impairment.

Sewage and other Oxygen Demanding Wastes: Management of solid waste is not successful due to huge volumes of organic and non-biodegradable wastes generated daily. As a consequence, garbage in most parts of India is unscientifically disposed and ultimately leads to increase in the pollutant load of surface and groundwater courses. Sewage can be a fertilizer as it releases important nutrients to the environment such as nitrogen and phosphorus which plants and animals need for growth. Chemical fertilizers used by farmers also add nutrients to the soil, which drain into rivers and seas and add to the fertilizing effect of the sewage. Together, sewage and fertilizers can cause a massive increase in the growth of algae or plankton that facilitate huge areas of oceans, lakes, or rivers creating a condition known as algal bloom thereby reducing the dissolved oxygen content of water and killing other forms of life like fish.

Industrial Wastes: Many of the industries are situated along the banks of river such as steel and paper industries for their requirement of huge amounts of water in manufacturing processes and finally their wastes containing acids, alkalies, dyes and other chemicals are dumped and poured down into rivers as effluents. Chemical industries concerning with manufacture of Aluminium release large amount of fluoride through their emissions to air and effluents to water bodies. Fertilizer industries generate huge amount of ammonia whereas steel plants generate cyanide. Chromium salts are used in industrial process for the production of sodium dichromate and other compounds containing chromium. All such discharges finally arrive at water bodies in the form of effluents affecting human health and the organism living there.

Agro-chemical Wastes: In the agricultural sector, water and electricity for irrigation are subsidized for political reasons. This leads to wasteful flood irrigation rather than adoption of more optimal practices such as sprinkler and drip irrigation. Cropping patterns and farming practices also do not necessarily encourage the judicious use of water. There are losses of water due to breaches and seepage resulting in water logging and salinity. Agro-chemical wastes include fertilizers, pesticides which may be herbicides and insecticides widely used in crop fields to enhance productivity. Improper disposal of pesticides from field farms and agricultural activities contributes a lot of pollutants to water bodies and soils. Some of the pesticides are: DDT, Aldrin, Dieldrin, Malathion, Hexachloro Benzene etc. Pesticides reach water bodies through surface runoff from agricultural fields, drifting from spraying, washing down of precipitation and direct dusting and spraying of pesticides in low lying areas polluting the water quality. Most of them are non-biodegradable and persistent in the environment for long period of time. These chemicals may reach human through food chain leading to biomagnification.

Nutrient enrichment: The sources of nutrients in surface water can be divided broadly into natural and anthropogenic types. Contribution to pollution by natural source is low due to balance established by the natural system between the production and consumption of nutrients over the course of time. Anthropogenic sources of contaminants are contributed from agriculture, domestic and industrial wastes. Nutrient concentrations in streams and rivers have been strongly correlated with human land use and disturbance gradients. Both N and P enrichment have links with the agricultural and urban land uses in the watershed. Fluxes of total N in temperate-zone rivers surrounding the North Atlantic Ocean are highly correlated with net anthropogenic input of N in their watersheds (Howarth *et al*., 1996). Total N and nitrate fluxes and concentrations in rivers are also correlated with human population density (Howarth *et al*., 1996). Nitrogen fertilization is the main source of N in streams and rivers (Goolsby and Battaglin, 2001). Similarly, nutrient enrichment of aquatic systems from anthropogenic sources includes point and nonpoint sources (**Table 1**. adapted from Carpenter *et al*., 1998). In contrast to point sources of nutrients that are relatively easy to monitor and regulate, nonpoint sources such as livestock, crop fertilizers, and urban runoff exhibit more spatial and temporal variability. Following strong regulation of point source inputs in response to the Clean Water Act, nutrients from nonpoint sources are now the major source of water pollution in the United States (Carpenter *et al*., 1998).

Thermal pollution: Changes in water temperature adversely affect water quality and aquatic biota. Majority of the thermal pollution in water is caused due to human activities. Some of the important sources of thermal pollution are nuclear power and electric power plants, petroleum refineries, steel melting factories, coal fire power plant, boiler from industries which release large amount of heat to the water bodies leading to change in the physical, chemical and biological characteristics of the receiving water bodies. High temperature declines the oxygen content of water; disturbs the reproductive cycles, respiratory and digestive rates and other physiological changes causing difficulties for the aquatic life.

Oil spillage: Oil discharge into the surface of sea by way of accident or leakage from cargo tankers carrying petrol, diesel and their derivatives pollute sea water to a great extent. Exploration of oil from offshore also lead to oil pollution in water. The residual oil spreads over the water surface forming a thin layer of water-in-oil emulsion.

The disruption of sediments: Construction of dams for hydroelectric power or water reservoirs can reduce the sediment flow affecting adversely the formation of beaches, increases coastal erosion and reduces the flow of nutrients from rivers into seas (potentially reducing coastal fish stocks). Increased sediment flow can also create a problem. During construction work, soil, rock, and other fine powders sometimes enter nearby rivers in large quantities, causing water to become turbid (muddy or silted). The extra sediment can block the gills of fish, causing them suffocation.

Acid rain pollution: Water pollution that alters a plant's surrounding pH level, such as due to acid rain, can harm or kill the plant. Atmospheric Sulfur dioxide and nitrogen dioxide emitted from natural and human-made sources like volcanic activity and burning fossil fuels\interact with atmospheric chemicals, including hydrogen and oxygen, to form sulfuric and nitric acids in the air. These acids fall down to earth through precipitation in the form of rain or snow. Once acid rain reaches the ground, it flows into waterways that carry its acidic compounds into water bodies. Acid rain that collects in aquatic environments lowers water pH levels and affects the aquatic biota.

Radioactive waste: Radioactive pollution is caused by the presence of radioactive materials in water. They are classified as small doses which temporary stimulate the metabolism and large

doses which gradually damage the organism causing genetic mutation. Source may be from radioactive sediment, waters used in nuclear atomic plants, radioactive minerals exploitation, nuclear power plants and use of radioisotopes in medical and research purposes.

Introduction of Alien species

In some parts of the world, alien species also known as invasive species are a major problem of water pollution. Outside their normal environment, they have no natural predators, so they rapidly spread and dominate the animals or plants that thrive there. Common examples of alien species include zebra mussels in the Great Lakes of the USA, which were carried there from Europe by ballast water (waste water flushed from ships). The Mediterranean Sea has been invaded by a kind of alien algae called *Caulerpa taxifolia*. In the Black Sea, an alien jellyfish called *Mnemiopsis leidyi* reduced fish stocks by 90 percent after arriving in ballast water. In San Francisco Bay, Asian clams called *Potamocorbula amurensis*, also introduced by ballast water, have dramatically altered the ecosystem.

Climate Change

Global warming has also an impact on water resources through enhanced evaporation, geographical changes in precipitation intensity, duration and frequency (together affecting the average runoff), soil moisture, and the frequency and severity of droughts and floods. Future projections using climate models pointed out that there will be an increase in the monsoon rainfall in most parts of India, with increasing greenhouse gases and sulphate aerosols. Relatively small climatic changes can have huge impact on water resources, particularly in arid and semi-arid regions such as North-West India. This will have impacts on agriculture, drinking water, and on generation of hydroelectric power, resulting in limited water supply and land degradation. Apart from monsoon rains, India uses perennial rivers which originate in the Hindukush and Himalayan ranges and depend on glacial melt-waters. Since the melting season coincides with the summer monsoon season, any intensification of the monsoon is likely to contribute to flood disasters in the Himalayan catchment. Rising temperatures will also contribute to a rise in the snowline, reducing the capacity of these natural reservoirs, and increasing the risk of flash floods

during the wet season. Increase in temperatures can lead to increased eutrophication in wetlands and fresh water supplies (CPCB Report, 2013).

Effects of water pollution: Polluted water has effects on both human and aquatic life.

1. **Effect of water pollution on human health**

-Chemicals in water that affect human health: Some of the chemicals affecting human health are the presence of heavy metals such as *Fluoride*, *Arsenic*, *Lead*, *Cadmium*, *Mercury*, petrochemicals, chlorinated solvents, pesticides and nitrates. *Fluoride* in water is essential for protection against dental carries and weakening of the bones. Concentration below 0.5 mg/l causes dental carries and mottling of teeth but exposure to higher levels above 0.5 mg/l for 5-6 years may lead to adverse effect on human health leading to a condition called *fluorosis*. *Arsenic* is a very toxic chemical that reaches the water naturally or from wastewater of tanneries, ceramic industry, chemical factories and from insecticides such as lead arsenate, effluents from fertilizers factories and from fumes coming out from burning of coal and petroleum. *Arsenic* is highly dangerous for human health causing respiratory cancer, arsenic skin lesion from contaminated drinking water in some districts of West Bengal. Long exposure leads to bladder and lungs cancer. *Lead* is contaminated in the drinking water source from pipes, fitting, solder, household plumbing systems. In the human beings, it affects the blood, central nervous system and the kidneys. Child and pregnant women are mostly prone to lead exposure. *Mercury* is used in industries such as smelters, manufactures of batteries, thermometers, pesticides, fungicides etc. The best known example of Mercury pollution in the oceans took place in 1938 when a Japanese factory discharged a significant amount of mercury into Minamata Bay, by contaminating the fish stocks there. It took several years to show its effects. By that time, many local people had eaten the fish and around 2000 were poisoned,hundreds of people were left dead and disabled (Akio, 1992) and the cause for death was named as "*Minamata disease*" due to consumption of fish containing methyl mercury. It causes chromosomal aberrations and neurological damages to human. Mercury shows biological magnification in aquatic ecosystems. *Cadmium* reaches human body through food crop from soil irrigated by affected effluents. Friberg *et al*. (1974) noted that long term consumption of rice from affected fields by the people living in areas contaminated by cadmium in regions of Japan, resulted into many renal diseases like "*itai-itai disease*", nephritis and nephrosis.

-Water borne disease: Microorganisms play a major role in water quality and the microorganisms that are concerned with water borne diseases are *Salmonella sp.*, *Shigella sp.*, *Escherichia coli* and *Vibrio cholera* (Adetunde and Glover, 2010). All these cause typhoid fever, diarrhoea, dysentery, gastroenteritis and cholera. The most dangerous form of water pollution occurs when faeces enter the water supply. Many diseases are perpetuated by the faecal-oral route of transmission in which the pathogens are shed only in human faeces (Adetunde and Glover, 2010). Presence of faecal *coliforms* of *E. coli* is used as an indicator for the presence of any of these water borne pathogens (Adetunde and Glover, 2010). Larry (2006) suggested that ground water contamination is the leading worldwide cause of deaths and diseases, and that it accounts for the deaths of more than 14,000 people daily, and the majority of them being children under 5 years old. In recent years, the widespread reports of pollutants in groundwater have increased public concern about the quality of groundwater. Children are generally more vulnerable to intestinal pathogens and it has been reported that about 1.1 million children die every year due to diarrhoeal diseases (Steiner and Gurrant, 2006).

2. Effect of water pollution on plants

The following are the effects of water pollution on plants:

i. *Effects of acid deposition*: Many of the gases from acid, aerosols and other acidic substances released into the atmosphere from industrial or domestic sources of combustion from fossil fuels finally fall down to ground and reach the water bodies along with run-off rainwater from polluted soil surfaces thereby causing acidification of water bodies by lowering its pH . In many countries chemical substances like sulphates, nitrates and chloride have been reported to make water bodies such as lakes, river and ponds acidic.

ii. *Nutrient deficiency in aquatic ecosystem*: Population of decomposing microorganisms like bacteria and fungi decline in acidified water which in turn reduces the rate of decomposition of organic matter affecting the nutrient cycling. The critical pH for most of the aquatic species is 6.0. The diversity of species decline below this pH whereas the number and abundance of acid tolerant species increases. Proliferation of filamentous algae rapidly forms a thick mat at the initial phase of the acidification of water. Diatoms and green algae disappear below pH 5.8. *Cladophora* is highly acid tolerant species and is

abundant in acidic freshwater bodies. Macrophytes are generally absent in acidic water as their roots are generally affected in such water resulting in poor plant growth. *Potamogeton pectinalis* is found in acidified water. It is observed that plants with deep roots and rhizomes are less affected while plants with short root systems are severely affected in acidic water.

iii. *Effects of organic matter deposition*: Organic matter from dead and decaying materials of plants and animals is deposited directly from sewage discharges and washed along with rainwater into water bodies causing increase in decomposers / microbes such as aerobic and anaerobic bacteria. Rapid decomposition of organic matter increase nutrient availability in water favouring the luxuriant growth of planktonic green and blue-green algal bloom. In addition many of the macrophytes like *Salvinia*, *Azolla*, *Eicchhornia* etc. grow rapidly causing reduced penetration of light into deeper layer of water body with gradual decline of the submerged flora . This condition results in reducing the dissolved Oxygen and increase in the biological oxygen demand (B.O.D). The B.O.D of unpolluted fresh water is usually below 1mg/l while that of organic matter polluted water is more than 400 mg/l.

iv. *Effects of detergent deposition*: Detergents from domestic and industrial uses wash down into water bodies causing serious effects on plants. Detergents contain high phosphates which results in phosphate-enrichment of water. Phosphates enter the plants through roots or surface absorption causing retarded growth of plants, elongation of roots, carbon dioxide fixation, photosynthesis, cation uptake, pollen germination and growth of pollen tubes, destruction of chlorophylls and cell membranes and denaturation of proteins causing enzyme inhibition in various metabolic processes.

v. *Effects of agricultural chemicals*: Chemicals from fertilizers, pesticides, insecticides, herbicides etc. applied to crops in excess are washed away with rainwater as runoff, then enter into soil and finally arrive at the water bodies. Chemicals from fertilizers result in eutrophication by enrichments of nutrients. Ammonium from fertilizers is acidic in nature causing acidification of water. Similarly pesticides, herbicides and insecticides also cause change in pH of the water bodies. Most common effect of these substances is the reduction in photosynthetic rate. Some may uncouple oxidative phosphorylation or inhibit

nitrate reductase enzyme. The uptake and bioaccumulation capacities of these substances are great in macrophytic plants due to their low solubility in water.

vi. *Effects of industrial wastes*: Effluents from industries contain various organic and inorganic waste products. Fly ash form thick floating cover over the water thereby reducing the penetration of light into deeper layers of water bodies. Fly ash increases the alkalinity of water and cause reduced uptake of essential bases leading to death of aquatic plants. Liquid organic effluents change the pH of water and the specific toxicity effects on the aquatic plants vary depending on their chemical composition. There may be synergistic, additive or antagonistic interactions between metals with respect to their effects on plants however these effects are reduced in hard and buffered freshwater bodies.

vii. *Effects of silt deposition*: Deposition of silt in water bodies occurs as a result of erosion carrying silt laden water and due to flood. It increases the turbidity of water and reduces light penetration in deep water causing decline in abundance of submerged plants. Siltation inhibits the growth of aquatic plants. Abundance of phytoplankton is affected due to reduction in surface exchange of gases and nutrients. Plants that are tolerant to turbidity are abundant followed by those that are intermediate and the least tolerant species. Plants such as *Polygonum, Sagittaria* etc. are found to grow in dominance.

viii. *Effects of oil spillage*: Oil pollution due to spillage of oil tankers and storage containers prevents oxygenation of water and depletes the oxygen content of the water body by reducing light transmission inhibiting the growth of planktons and photosynthesis in macrophytes.

ix. *Effects of thermal pollution*: The release of heated water into water bodies from the thermal power plants has an adverse effect on the aquatic life. It reduces the activity of aerobic decomposers due to oxygen depletion because of high temperature. With decreased organic matter decomposition , the availability of nutrients in the water bodies is jeopardised. Aquatic plants show reduced photosynthesis rate due to inhibition of enzyme activity with increased temperature. Primary productivity and diversity of aquatic plant species decline because of increased temperature of water bodies as a result of thermal pollution.

x. *Effect of nutrient enrinchement*: Nutrient enrichment in aquatic water bodies leads to eutrophication which is a process whereby water bodies receive excess inorganic nutrients, especially N and P, stimulating excessive growth of plants and algae. Eutrophication can happen naturally in the course of normal succession of some freshwater ecosystems. However, when the nutrient enrichment is due to the activities of humans, it is referred to as "*cultural eutrophication*", where the rate of nutrient enrichment is greatly intensified. Eutrophication was recognized as a pollution problem in North American lakes and reservoirs in the mid 20^{th} century (Rohde, 1969). Plants must take in nutrients from the surrounding environment inorder to grow. Nitrogen and phosphorous, in particular, encourage growth because they stimulate photosynthesis. This is why they are common ingredients in plant fertilizers. When agricultural runoff pollutes waterways with nitrogen and phosphorous rich fertilizers, the nutrient-enriched waters often paves way to algal bloom leading to eutrophication.The result is oxygen depletion and dying of fishes due to suffocation.

xi. *Phytotoxicity effects on plants*: When chemical pollutants build up in aquatic or terrestrial environments, plants can absorb these chemicals through their roots. Phytotoxicity occurs when toxic chemicals poison plants. The symptoms of phytotoxicity on plants include poor growth, dying seedlings and dead spots on leaves. For example, mercury poisoning which many people associate with fish can also affect aquatic plants, as mercury compounds build up in plant roots and bodies result in bioaccumulation.As animals feed on polluted food the increasing levels of mercury is built up through food chain.

Control of Water Pollution

The key challenges to better management of the water quality in India comprise of temporal and spatial variation of rainfall, uneven geographic distribution of surface water resources, persistent droughts, overuse of ground water and contamination, drainage and salinisation and water quality problems due to treated, partially treated and untreated wastewater from urban settlements, industrial establishments and runoff from irrigation sector besides poor management of municipal solid waste and animal dung in rural areas (CPCB Report, 2013). Some of the control measures are given below:

1. The Ganga Action Plan and the National River Action Plan are being implemented for addressing the task of trapping, diversion and treatment of municipal wastewater.
2. In most parts of the country, waste water from domestic sources is hardly treated, due to inadequate sanitation facilities. This waste water, containing highly organic pollutant load, finds its way into surface and groundwater courses near the vicinity of human habitation from where further water is drawn for use. Considerable investments should be done to install the treatment systems.
3. With rapid industrialization and urbanization, the water requirement for energy and industrial use is estimated to rise to about 18 per cent (191 bcm) of the total requirements in 2025 (CPCB Report, 2013). Poor environmental management systems, especially in industries such as thermal power stations, chemicals, metals and minerals, leather processing and sugar mills, have led to discharge of highly toxic and organic wastewater. This has resulted in pollution of the surface and groundwater sources from which water is also drawn for irrigation and domestic purpose. The enforcement of regulations regarding discharge of industrial wastewater and limits to extraction of groundwater needs to be considerably strengthened, while more incentives are required for promoting waste water reuse and recycling.
4. For the agricultural sector, water and electricity for irrigation are subsidized for political reasons. This leads to wasteful flood irrigation rather than adoption of more optimal practices such as sprinkler and drip irrigation. Optimized irrigation, cropping patterns and farming practices should be encouragde for judicious use of water.
5. The water quality management in India is accomplished under the provision of Water (Prevention and Control of Pollution) Act, 1974 that was amended in 1988. The basic objective of this Act is to maintain and restore the wholesomeness of national aquatic resources by prevention and control of pollution. The Water (Prevention and Control of Pollution) Cess Act was enacted in 1977, to provide for the levy and collection of a cess on water consumed by persons operating and carrying on certain types of industrial activities.
6. The Central Pollution Control Board (CPCB) has established a network of monitoring stations on aquatic resources across the country. The water quality monitoring and its management are governed at state/union territory level in India. The network covers 28 states

and 6 Union Territories (CPCB Report, 2013). Water quality monitoring is therefore an imperative prerequisite in order to assess the extent of maintenance and restoration of water bodies.

7. There should be ban on washing of clothes and laundry alongside the river bank.
8. Industries should install Effluent Treatment Plant (ETP) to control the pollution at source.
9. All towns and cities must have Sewage Treatment Plants (STPs) that clean up the sewage effluents.
10. Improper use of fertilizers, herbicides and pesticides in farming should be stopped and organic methods of farming should be adoped. Cropping practices in riparian zone should be banned to protect the riparian vegetation growing there.
11. Religious practices that pollute river water by dumping colourful paints of idols containing harmful synthetic chemicals should be stopped.
12. Rain water harvesting should be practiced to prevent the depletion of water table.
13. Making people aware of the problem is the first step to prevent water pollution. Hence, importance of water and pollution prevention measures should be a part of awareness and education programme.
14. *Polluter pays principle* should be adopted so that the polluters will be the first people to suffer by way of paying the cost for the pollution. Ultimately, the *polluter pays principle* should be designed to prevent people from polluting and making them behave in an environmentally responsible manner.
15. As riparian vegetation helps in making the river water clean because of the multiple functions, to prevent people from felling and clearing down of riparian forest zones for road construction, agricultural practices, recreational and tourism , sand mining, quarrying and clay mining etc. community should play a regulatory role.

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