Research Article

Global Status of Nitrate and Heavy Metals in the Ground Water with Special Reference to Rajasthan

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Abstract

At the advent of the 21st Century humanity approaches crises of cries. The new century is clouded by unheard of perils to the permanence of the natural World. In a globally interconnected economy, fast deforestation, falling water table and erratic climate change could harm economies around the World in the decades to follow. Water pollution has become a major problem in India in recent years, especially in and around industrial and urban centers. Only limited surveys of quality have been carried out so far and, therefore, quantitative data in respect of water pollution is meager. However, the studies conducted by the All India Institute of Hygiene and Public Health, Calcutta, and NEERI, Nagpur, and its zonal stations, have shown that only few industries have constructed waste-treatment plants. Even these are not properly operated. This review describes the Global Status of Nitrate and Heavy Metals in the Ground Water with Special Reference to Rajasthan.

Keywords: Pollution, Waste treatment, Global, Nitrate, Heavy metals

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Introduction

Environment is the depot of materials and processes that the society transforms into goods and services (wealth) and its receptacle for refuse and waste matter formed as excreta of societal activities and physiology; here we recognize issues related to resources, growth and sustainable development. Environmental issues, whether related to resources or quality may have limited dimensions in space (a ward in a factory, a crop field or a smoking compartment in a train) or may have wider extent (a city, a lake or a semi closed sea). Widespread issues may be Worldwide in the extent and thus qualify for the little global. It has been noted that issues of limited scale are often simple, whereas widespread issues are often compound and multifaceted.

Environmental pollution is the unfavorable alteration of our surroundings, wholly or largely as a byproduct of mine's actions, through direct or indirect effects of the changes in the energy pattern, radiation levels, chemical and physical constitutions and abundance of organisms. Environmental pollution is a global problem and is common to both developed as well as developing countries. The decline in environmental quality as a consequence of pollution is evidenced by the loss of vegetable cover and biological diversity, excessive concentration of harmful chemicals in the ambient atmosphere and food grains, growing risks of environmental accidents and threats to life support systems.

Men's activities disturbed the eco-balance by deteriorating the environmental conditions suitable to sustain life and cause pollution. Any undesirable change in the physical, chemical or biological characteristics of air, water, and soil, may create a hazard or potential hazard to the health, safety or welfare of any living species is called pollution [1-3].

Water

Water is everywhere – even in the air! Water is very important in our daily lives. We drink it, bathe in it, use it for leisure or in other uses depend on it throughout our life, yet we waste it. Yes, we do indeed. Water has different structures. Its two hydrogen atoms do not circle its oxygen at 180^o angle, but at a 104^o 25' angle (V-shaped) when it is in liquid form, and at a 109º5' angle (cage like, tetrahedral) when it takes the form of ice. At 10ºC, pure distilled water is 96% to 97% pentagonal structured. In this type of structured water, namely the distilled, fish, algae and plankton will die [4, 5].

Water moves from one reservoir to another by way of processes like evaporation, condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, melting, and groundwater flow. The oceans supply most of the evaporated water found in the atmosphere. Of this evaporated water, only 91 % is returned to the ocean basins by way of precipitation. The remaining 9% is transported to areas over landmasses where climatologically factors induce the formation of precipitation. The resulting imbalance between rates of evaporation and precipitation over land and ocean is corrected by runoff and groundwater flow to the oceans (**Figure 1**)

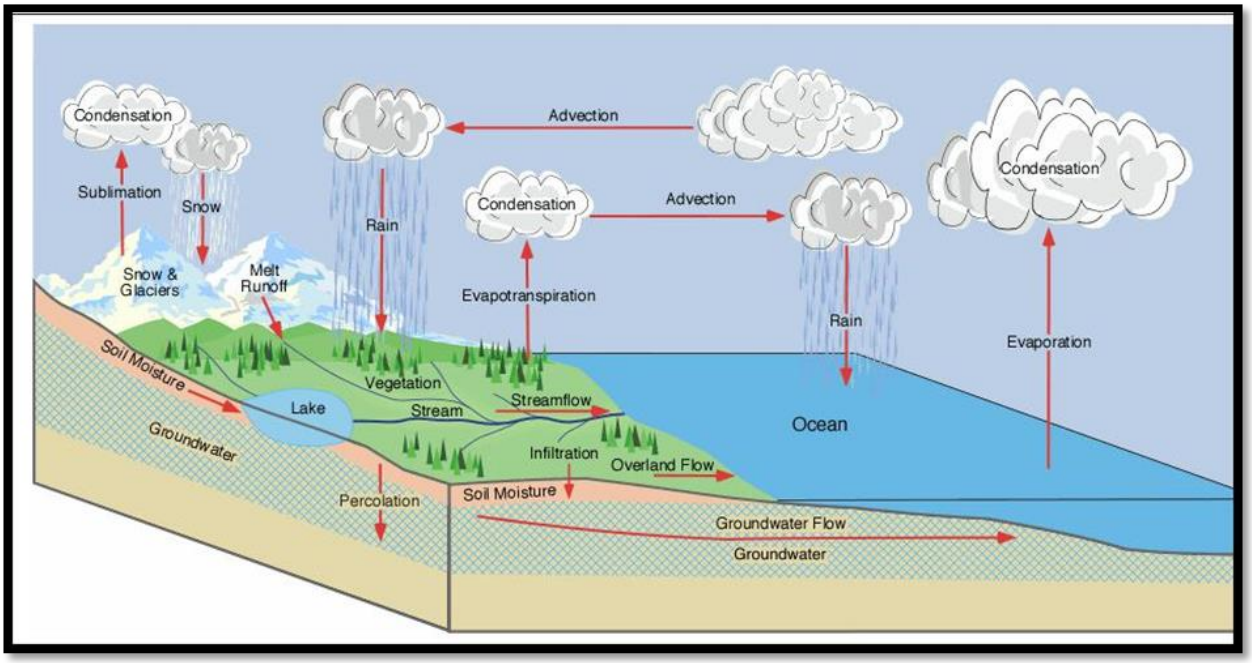

Figure 1 The hydrologic cycle

The planetary water supply is dominated by the oceans. Approximately 97 % of all the water on the Earth is in the oceans. The other 3 % is held as freshwater in glaciers and icecaps, groundwater, lakes, soil, the atmosphere, and within life [6].

Water Availability

"Protecting our ground water for our children is a challenge and we all must accept and struggle together if we are to succeed. The time for action is now". The total amount of water on the earth is about 1400 million cubic kilometers. Of this, 97.5% is sea water. About 75% of the remaining fresh water is locked up as ice caps and glaciers and further about 24% is locked underground as ground water. Ground water accounts for about 8×106 m^3 or 0.6% of earth's total water resources (**Table 1**).

Table 1 Inventory of water at the earth's surface

Reservoir	Volume (cubic km x 1,000,000)	Percent of Total
Oceans	1370	97.25
Ice Caps and Glaciers	29	2.05
Groundwater	9.5	0.68
Lakes	0.125	0.01
Soil Moisture	0.065	0.00886
Atmosphere	0.013	0.001
Streams and Rivers	0.0017	0.0001
Biosphere	0.0006	0.00004

Water is continually cycled between its various reservoirs. This cycling occurs through the processes of evaporation, condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, melting, and groundwater flow. **Table 2** describes the approximate residence times of water in the major reservoirs. On average water is renewed in rivers once every 16 days. Water in the atmosphere is completely replaced once every 8 days. Slower rates of replacement occur in large lakes, glaciers, ocean bodies and groundwater. Replacement in these reservoirs can take from hundreds to thousands of years. Some of these resources (especially groundwater) are being used by humans at rates that far exceed their renewal times. This type of resource use is making this type of water effectively nonrenewable [6].

India, the land of about 329 million hectare (m ha) is drained through 24 major river basins and groups of smaller river basins. The annual water cycle depends on the rains throughout the country and snowfall in north India. There are very few natural surface lakes in the country. The snow serves as a reservoir in the higher Himalaya, feeding some of the glaciers in the Indus, Ganga and a small part of Brahmaputra basin upper reaches.

Table 2 Approximate residence time of water found in various reservoirs.

Reservoir	Average Residence Time
Glaciers	40 years
Seasonal Snow Cover	0.4 years
Soil Moisture	0.2 years
Groundwater: Shallow	200 years
Groundwater: Deep	10,000 years
Lakes	100 years
Rivers	0.04 years

On the whole, the water balance in individual basins and the country is adverse, incanting high run off in monsoon, smaller infiltration and low recharge, very low river flow in lean seasons and low ground water potential. Water source, thus, can be summarized as: rainfall, other forms of precipitation, snow and dew. Annual rainfall over the entire country is estimated just over 400 Million hectare meter (M ha m) about 70 M ha m is lost by evaporation, roughly 215 M ha m seeps into the soil, about 115 M ha m flow in to the river system, lakes and tanks, remaining about 50 M ha m percolates into the porous strata and contribute for annual enrichment of underground water and proportion of run-off, percolation and evaporation vary considerably, influenced by the seasons, geological and topographical features of the area [6,7].

Water Quality

Water quality is a term used to describe the chemical aesthetic, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose. Although scientific measurements are used to define water's quality, it's not a simple thing to say that "this water is good" or "this water is bad". A healthy environment is one in which the water quality supports a rich and varied community of organism and protects public health [8-11]. Water quality has becomes a very big issue today, partly because of the tremendous growth of the Nation's population and urban expansion and development. Rural areas can also contribute to water quality problems [7]. If water quality is not maintained, it is not just the environment that will suffer. The commercial and recreational values of our water resources will also diminish [8, 12].

Water Quality Management

Abstractive use of water requires adherence to the desired water quality norms, which are designed as guidelines as well as standards .All the abstractive uses of water return a quantity of water to the water bodies. The water returned to water bodies is changed in quality and adversely affect the water bodies. Thus, appropriate treatment is essential to control water quality after abstraction and before discharge in water bodies. The wastewater discharge of most of the industries is the subject of vigilance and enforcement as the wastewater treatment is neglected. This untreated industrial waste is the cause of serious pollution of surface water as well as ground water [7, 13, 14].

Water Resources Management

The country's water availability in absolute terms is more than the world average. Because of extreme variability, it is not useable unless impounded during rainy season and in case of ground water unless it is pumped out without exceeding the natural recharge. Both, together, constitute yearly renewable resource. The surface water feeds ground water, which in turn releases it after an extended residence period into surface base flow. A natural water resource, which is not put to any use, may be used as and where it is available naturally. Appropriate movement and impoundment of the water may be reducing vulnerability to the droughts and floods. A peak of flood flow in rivers are reduced due to absorption in reservoirs assisting better flood management availability of water resources in India and is estimated to satisfy the required ultimate needs, but it involves sound decisions [7].

Pure Water

We know that all life is dependent on water and that water exists in nature in many forms like clouds, rain, snow, ice, and fog. However, strictly speaking, chemically pure water does not exist for any appreciable length of time in nature. Even while falling as rain, water picks up small amounts of gases, ions, dust, and particulate matter from the atmosphere. Then, as it flows over or through the surface layers of the earth, it dissolves and carries with it some of almost everything it touches, including that which are dumped into it by man. These added substances may be arbitrarily classified as biological, chemical (both inorganic and organic), physical, and radiological impurities. They include industrial and commercial solvents, metal and acid salts, sediments, pesticides, herbicides, plant nutrients, radioactive materials, road salts, decaying animal and vegetable matters, and living microorganisms, such as algae, bacteria, and viruses. These impurities may give water a bad taste, color, odor, or cloudy appearance (turbidity), and cause hardness, corrosiveness, staining, or frothing. They may damage growing plants and transmit disease. Many of these impurities are removed or rendered harmless; however, in municipal drinking water treatment plants, pure water means different things to different people.

Homeowners are primarily concerned with domestic water problems related to color, odor, taste, and safety to family health, as well as the cost of soap, detergents, "softening," or other treatments required for improving the water quality. Chemists and engineers working for industry are concerned with the purity of water as it relates to the scale deposition and pipe corrosion. Regulatory agencies are concerned with the setting standards to protect the public health. Farmers are interested in the effects of irrigation waters on the chemical, physical, and osmotic properties of soils, particularly as they influence crop production; hence, they are concerned with the water's total mineral content, proportion of sodium, or content of ions "toxic" to plant growth. One means of establishing and assuring the purity and safety of water is to set a standard for various contaminants.

A standard is a definite rule, principle, or measurement which is established by governmental authority. The fact that it has been established by authority makes a standard rigid, official, and legal; but this fact does not necessarily mean that the standard is fair or based on sound scientific knowledge. Where human health data or other scientific data are sparse, standards have sometimes been established on an interim basis until better information becomes available [6].

Water Pollution

When insoluble solid particles, soluble salts, sewage, garbage, low level radioactive substances, industrial wastes, algae and bacteria go into water, water get polluted. This type of pollution is called water pollution [15]. It is to dispose of waste by dumping it into a river or lake. In large or small amounts, deemed intentionally or accidentally, it may be carried away by the current, but will never disappear. Freshwater bodies have an immense ability to break down some waste materials whether chemically or thank to the routine actions of living organizations. In the latter case, energy from sunlight drives the process of photosynthesis in aquatic plants, producing oxygen that other organisms uses to break down some of the organic material such as plant and animal waste. The decomposition produces carbon dioxide, nutrients and other substances needed by plants and animals living in the water.

Unfortunately, the quantities discarded by today's society are by far exceeding the self- cleaning capacity of water bodies. The overload that results, called pollution, eventually puts the ecosystem out of balance and is of great environmental concern. Our waterways are being polluted by municipal, agricultural and industrial wastes, including many toxic synthetic chemicals which cannot be broken down at all by the natural process. Even in the tiny amounts, some of these substances can cause serious harm. In fact, of the almost 10 million chemicals known today, approximately 100000 chemicals are used commercially.

Position of Nitrate and Fluoride Pollution

In India several states have ground water containing excessive amount of fluoride. These include Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan, Delhi, Karnataka, Gujarat, Maharashtra, Orissa, Haryana, Tamilnadu and Bihar. There are thousands of people and children's in the various states of India suffering from fluorosis. The fluorosis is a non-curable disease; hence it needs quick prevention as about 52% villages in Rajasthan are affected by the fluorosis shown in **Figure 2** and fluoride levels in few districts of Rajasthan (**Table 3**).

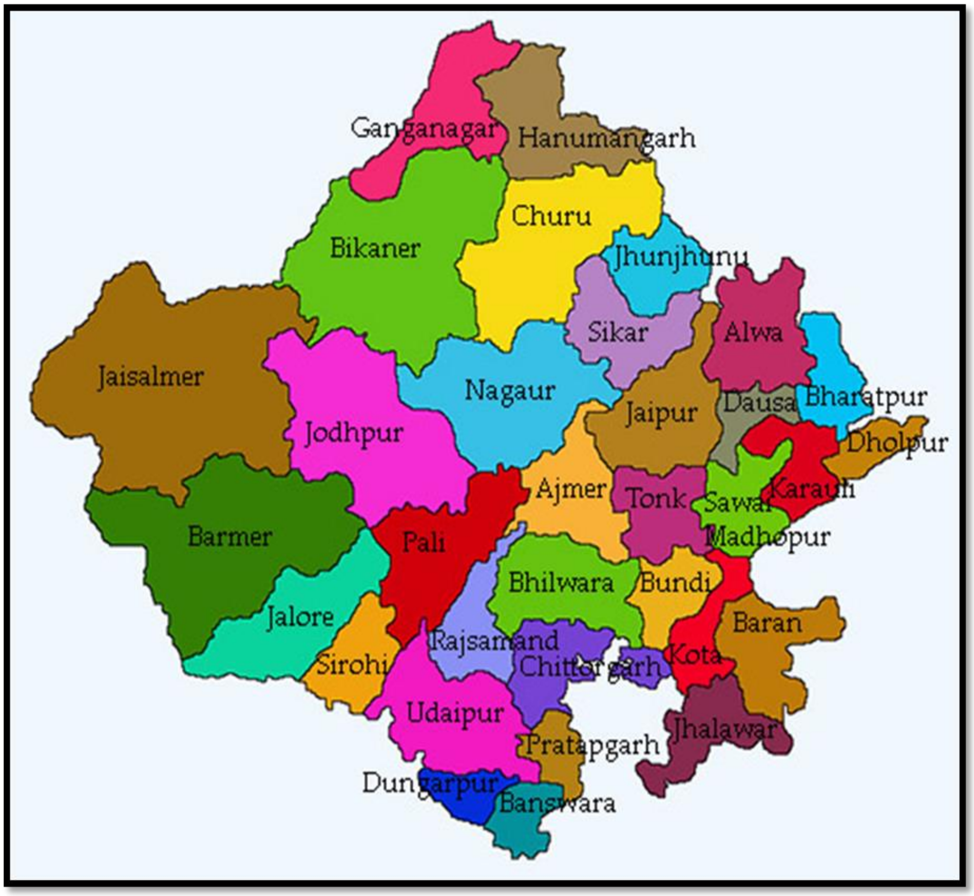

Figure 2 Fluoride map of the Rajasthan

Table 3 Fluoride levels in few districts of Rajasthan

Degree of Problem	**District in Map**	**Percent Villege/Habitation**	
		In Fluoride	Range of >3.0 mg/L
Very Serious	Jalore, Nagaur, Ajmer, Jaaipur, Tonk, Dausa	28-53%	>10%
Serious	Jaisalmer, Barmer, Sirohi, Pali, Bhilwara, Sikar, Alwar, Bharatpur, S. Madhopur, Dungarpur	18-34%	5-10%
Less Serious	S. Ganganagar, Hanumangarh, Churu, Jhunjhunu, Dholpur, Jodhpur, Udaipur, Rajsamand, Banewar	9-20%	2-5%
Insignificant	Bikaner, Chittorgarh, Bundi, Baran, Kota, Jahlawar	2-9%	0-2%

Center for health effects of environmental contamination, the University of Lowa, Agriculture at risk, delivered a report to the nation which included a brief discussion of nitrate in the environment as a risk factor for human health. Specifically, the contribution from nitrogen containing fertilizers to the high levels of nitrate in the food and drinking water was identified as an environmental health concern. Nitrate levels distributions are shown in **Figures 3** and **4** [16, 17].

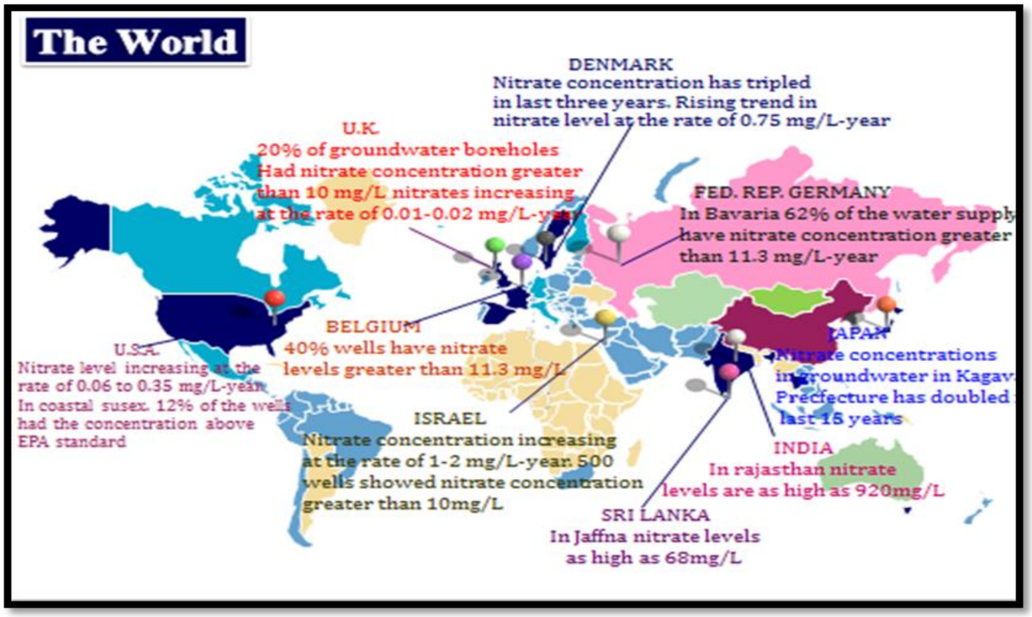

Figure 3 Significant levels and trends of nitrate few countries of the world

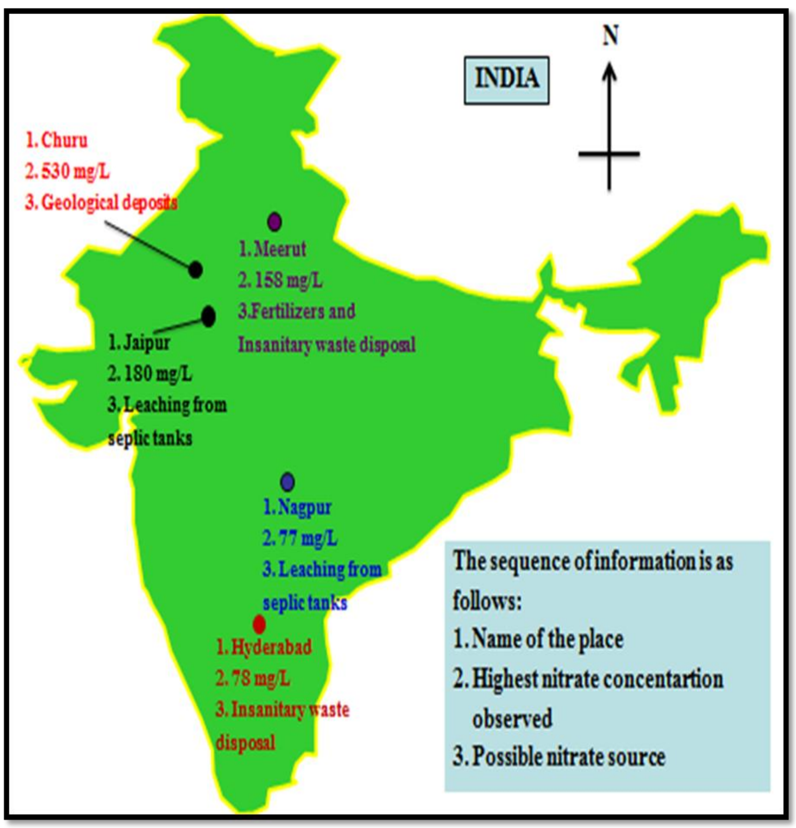

Figure 4 Nitrate content in few cities of India

Worldwide trends of nitrate and heavy metals contamination of ground water

Nitrate

Nitrate levels have gradually increased in many European countries in last few decades. Ground water is an important national resource, providing drinking water for more than one-half of the people in the United States (Solley and others, 1993). Additionally, ground water accounted for 39 percent of water withdrawn to supply cities and towns and 96 percent of water withdrawn by private users in 1990 [18].

Ground water is vulnerable to contamination by chemicals, including nitrate that can pass through soil to the water table. Nitrate comes from nitrogen supplied primarily by inorganic fertilizer and animal manure. Additionally, airborne nitrogen compounds emitted by industry and automobiles are deposited on the land in precipitation, gases, and dry particles (Puckett, 1994). Nitrate is soluble in water, can easily leach through soil, and can persist in shallow ground water for decades [19].

Ingestion of nitrate in drinking water by infants can cause low oxygen levels in the blood, a potentially fatal condition [20]. For this reason, the U.S. Environmental Protection Agency (USEPA) has established a maximum contaminant level (MCL) of 10 milligrams per liter (mg/l) nitrate as nitrogen [21]. Additional adverse health effects have been implicated in recent studies of contaminated ground water. A case study in Indiana indicated that nitrate concentrations of 19-29 mg/l in rural, domestic wells might have caused eight spontaneous abortions among four women during 1991-1994 [22]. Nitrate concentrations of 4 mg/l or more in water from community wells in Nebraska have been associated with increased risk of non-Hodgkin's lymphoma [23]. Nitrate concentrations in natural ground waters commonly are 2 mg/l or less [24].

Nitrate levels have gradually increased in many European countries in the last few decades and have doubled over the past 20 years in United Kingdom, recording an average annual increase of 0.7 mg/l (Ashour et al., 1994). The natural nitrate concentration in groundwater under aerobic conditions is a few milligrams per litre and depends strongly on soil type and on the geological situation. In most European countries, nitrate levels in drinking water due to discharge of industrial waste and agricultural activities, is exceeding the WHO guideline value of 50 mg NO3-/l. Poorly developed facilities for disposal of human and animal waste, which also give rise to poor hygienic water quality, appear to be the chief cause of increase in nitrate concentration in ground water [25].

In the USA, naturally occurring levels do not exceed 4-9 mg/l for nitrate and 0.3 mg/l for nitrite. But as a result of agricultural activities, the nitrate concentration can easily reach several hundred milligrams per litre [26].

Contamination of the ground waters of the Abbotsford Aquifer by nitrates have been observed by Environment Canada and others since the early 1950s [27]. A monitoring program for the area of the Aquifer south of Abbotsford, B.C., was developed by Environment Canada in the early 1980s and a number of sites in this study area have been sampled regularly. Since 1992, the average concentrations of nitrate (expressed as nitrogen or nitrate-N in this indicator) observed at these sites has frequently exceeded the 10 mg/l (Guideline for Canadian Drinking Water Quality). Of 2,757 ground water samples collected from monitoring wells called piezometers, 71% of these study area samples have exceeded the 10 mg/l nitrate as nitrogen guideline with individual values ranging from a low of 0.03 mg/l to a high of 91.9 mg/l.

The large range in maximum and minimum nitrate concentrations reflects the different conditions observed at different piezometers. Nitrate concentrations in some piezometers fluctuated above and below the nitrate guidelines, while in others they were consistently below or above the guidelines. The maximum nitrate concentrations measured in 1996, 1997 and 1998 were from samples taken from one piezometer. Nitrate concentrations can be very site specific and dependent on the local soil characteristics, topography and the land use activities near and up-gradient from the sampling site. Precipitation recharges or adds water to the aquifer, and the leaching of nitrogen compounds from the soil to the ground water as water percolates downward has an effect on nitrate values.

Ground water provides drinking water for more than one-half of the Nation's population [28], and is the sole source of drinking water for many rural communities and some large cities. In 1990, ground water accounted for 39 percent of water withdrawn for public supply for cities and towns and 96 percent of water withdrawn by self-supplied systems for domestic use [29].

A variety of chemicals, including nitrate, can pass through the soil and potentially contaminate ground water. Nitrate comes from nitrogen, a plant nutrient supplied by inorganic fertilizer and animal manure. Additionally, airborne nitrogen compounds given off by industry and automobiles are deposited on the land in precipitation and dry particles. Other nonagricultural sources of nitrate include lawn fertilizers, septic systems, and domestic animals in residential areas.

Beneath agricultural lands, nitrate is the primary form of nitrogen. It is soluble in water and can easily pass through soil to the ground-water table. Nitrate can persist in ground water for decades and accumulate to high levels as more nitrogen is applied to the land surface every year [30]. Areas with a high risk of ground-water contamination by nitrate generally have high nitrogen loading or high population density, well-drained soils, and less extensive woodland relative to cropland [31].

Ground water nitrate data collected by the U.S. Geological Survey's National Water Quality Assessment (NAWQA) Program were analyzed to verify the four risk groups. The NAWQA program was begun in 1991 to describe the quality of the Nation's water resources, using nationally consistent methods. Whereas prior verification work (Nolan and others, 1997) used historical nitrate data, the current analysis used data from more than 1,400 wells sampled by the NAWQA program during 1993-1995. Goulter [32] observed concentrations in New Zealand and found that the prevalence of nitrate fixing crops has more effect than application of fertilizers. Schenk [33] studied the problem in Germany and concluded that nitrate levels could fluctuate by large amounts over short periods of time. It was also suggested that transient peaks in nitrate concentration could lead to false conclusions concerning the quality of ground water.

Gabel et al. [34] found that in West Germany the limit 50 mg/l was exceeded for about 10 percent of population and that nitrate pollution was increasing continuously. In 1983, Darimont et al. [35] obtained drinking water samples from tap at 200 sites in wine growing areas of Badan and Wurtemberg, West Germany and found 13 percent of samples had nitrate content exceeding the standard limit.

In France the problem of nitrate pollution is taken very seriously. In 1985 around 2 to 5 million habitants were consuming nitrates in drinking water more than the standards limit. It was estimated that many countries in Europe and probably in the world, were suffering from nitrate pollution or were likely to do so in near future [36].

New Jersey has diverse environments that influence the nitrate concentrations in surface and ground water. These environments are agricultural practices that include cropland and livestock, industrial operations such as mining and construction, municipal, landfills and waste water treatment plants, and households with septic tanks and the improper disposal and use of cleaners, solvents, automobile and lawn maintenance products [37]. The heightened concern for reduction of environmental pollution that has been occurring over the past 20-25 years has stimulated active continuing research and literature on the toxicology of heavy metals. While the toxic effect of these substances is a widespread concern in the modern industrial context, Man has succeeded in poisoning himself with them repeatedly throughout recorded history. One historian/toxicologist contents that the fall of the Roman Empire was hastened by the chronic lead poisoning experienced by the ruling classes who had water conducted through lead plumbing and drank wine from goblets which had lead/alloy composition. Virtually all metals can produce toxicity when ingested in sufficient quantities, but there are several which are especially important because either they are so pervasive, or produce toxicity at such low concentrations. When speaking of heavy metals we generally mean, lead, mercury, iron, copper, manganese, cadmium, arsenic, nickel, aluminum, silver, and beryllium.

In general heavy metals produce their toxicity by forming complexes or "ligands" with organic compounds. These modified biological molecules lose their ability to function properly, and result in malfunction or death of the affected cells. The most common groups involved in ligand formation are oxygen, sulfur, and nitrogen. When metals bind to these groups they may inactive important enzyme systems, or affect protein structure [38, 39]. There are over 200,000 contaminated sites in the United States that received remediation. The estimated minimum cost for remediation, in 1999-2000 in dollars is $200 billion and can take from 10 to 30 years or longer.

Ground water contamination is involved in over 70 percent of the sites out of which over 50 percent contain heavy metal contaminants. Heavy metals pollution of ground water is an extremely serious environmental problem and a costly one to remediate. Government agencies and the private sector are interested in new technologies, which can economically and effectively remove heavy metals from the groundwater or wastewater.

Alkali Fly Ash – Permeable Reactive Barrier (AFA-PRB) is a new and innovative technology (constructed from fly ash that otherwise would has been land filled) that has the potential of removing lead (Pb) from contaminated water in an economically feasible manner. The overall objective of this work is to show technical feasibility and economic viability of AFA-PRB in removing lead from contaminated ground or surface water.

The planned work for the initial phase includes: 1) construction of AFA- with controlled permeability; 2) testing the ability of AFA-PRB in removal lead from contaminated water; 3) construction of bench scale AFA-PRB; 4) investigation of lead removal mechanisms. Preliminary work indicated that AFA-PRB can remove cadmium from highly contaminated water very effectively (up to 99 percent efficiency).

Ground water is widely used in Montana for domestic and other purposes. Non-point source contamination of ground water can have several causes, including septic systems, feedlots, manure storage facilities, crop-fallow systems, saline seeps, and leaching caused by irrigation or precipitation. While no widespread contamination of ground water in Montana has been attributed to fertilizer application, localized problems have been identified.

Ground water pollution is one of the major environmental challenges facing agriculture today, with contamination of shallow water tables being of particular concern. The USEPA has defined the maximum contaminant level of nitrate-N (NO3-N) for human consumption as 10 ppm. Nitrate-N concentration of ground water under grassland and forest is generally 2 ppm or less. In contrast, the NO3-N concentration in ground water under cropland is often greater than 2 ppm, commonly greater than 5 ppm, and has been measured at concentrations of over 100 ppm. The amount of fertilizer nitrogen (N) used in this country has greatly increased in the last 40 years. It has been suggested that increased use of fertilizer N, in combination with irrigation, has contributed to the increased NO3-N contamination of ground water.

Most of the Lower Yellowstone River Valley is irrigated, and the water table is shallow (4-20 ft). Nitrate-N concentrations in the ground water under sugar beet fields at the Eastern Agricultural Research Centre were monitored in 1971 and 1973. Nitrate concentrations fluctuated throughout the growing season, with the greatest concentrations, 25 ppm in 1971 and 4 ppm in 1973, occurring in July. The lowest levels in both the years measured in early October were less than 0.1 ppm.

A more recent study conducted from 1989-1995 monitored NO3-N in soil and ground water under irrigated small again, sugar beet, and safflower cropping systems after recommended fertilization. The crops were planted in three fields of about 20 acres each with a rotation of sugar beet-safflower-small grain. Conventional procedures for fertilization, tillage, and pest control were used for all crops. Each field was planted to all crops at least twice, and all crops were planted every year. The small grain crop was barley in 1989 and 1990, and spring wheat in all other years [40.41].

Metals occur in the earth's crust either in the elemental form or as compounds. Their distribution varies from place to place. The disturbance of the soil through activities such as mining, quarrying and other forms of excavations cause metals to be washed into water sources. Their usual sources in water are Industrial wastes, sewage, reuse leachate and the atmosphere.

Aluminium

Aluminium occurs naturally in water as a result of acid rain which dissolves it from rocks (BMA, 1990). Aluminium sulphate is widely used as a coagulant in water treatment. This constitutes a major fraction of the aluminium found in finished water, especially where a wrong dosage is applied. Aluminium could also enter water from the use of aluminium cooking utensils, pipes or tanks. According to Hunt and Fawell (1990), Greger (1985) estimated that if all cooking and handling of food involved uncoated aluminium products, upto 3.5 mg Al/l/day could be added to the diet [42, 43].

Iron

The earth's crust provides a major source of iron which is normally found in concentration of less than 5 mg/l in natural waters [44]. In aerated water, such as free flowing surface water, iron exists in the ferric state. But ground water or any water under reducing condition normally contain iron in the ferrous form. According to the WHO (1984) the presence of iron in natural water could be attributed to the dissolution of rocks and minerals, acid mine drainage, landfill leachates, sewage, or iron related industries [45].

Manganese

Manganese is closely related to iron in behavior. It is therefore quite common to find them reported together in many documents. Manganese is usually found in appreciable concentrations only in ground water or in the hypolimnion layer of a stratified lake where condition is anaerobic [46]. The common sources of manganese in nature are rocks and soils. It is also found in organic matter because it is a plant nutrient. Like iron, high values of manganese could exist in acid mine drainage because it is more soluble under acidic conditions.

Zinc

Zinc normally occurs in very small quantities in natural water because most of its salts are only sparingly soluble in water. According to Sawyer and McCarty [47], the main routes of zinc entrance into water are mining operations, waste water from electroplating, and the corrosion of galvanized piping. Because it is used expensively in the manufacture of pipes, brass and fittings, substantial amounts could be leached into piped water before it reaches the consumers.

Copper

Copper is found in soils, foods, pipes fittings, fertilizers, chemicals and other industrial products. It is rarely found in natural water. The use of copper sulphate for the control of algae in reservoirs and lakes is a common source of copper in water [48]. Most conventional techniques of water treatment usually lead to substantial reductions in levels of copper in finished water. But copper is leached out from the distribution system where copper and brass pipes and fittings are used [49].

Lead

The important sources of lead in natural water are the soil, the air, used lead products, the use of lead pipes and roofing materials is now being discouraged because they constitute a major source of lead entrance into water. In homes where lead pipes are still in service, plumb solvency could result if the supply is acidic or soft water (BMA, 1990). Plumb solvency is a process which involves the leaching of lead from pipes into distribution system.

Lead is commonly added to petrol as an anti-knocking agent to protect the engines of vehicles. Exhaust gases from such vehicles have become an issue of environmental concern because of their introduction of lead into the air. The final destination of such atmospheric lead is likely to be surface water as it is washed out in rain. This source of lead often arouses more environmental concern than the problem of domestic lead pipes [50].

Problems of Metals in Water

The problems of metals in water could be classified into health and aesthetic. Health problems relate to those metals which cause diseases when consumed by people at even small concentrations. For example, lead, cadmium and chromium are known to have some toxic effect on man. The aesthetic problems concerns metals which people object to their presence in water because they cause inconveniences or dislike for reasons other than health. The sort of aesthetic problems encountered in water supplies are discoloration, taste, staining and turbidity. The types of problems caused by the metals under study are shown in **Table 4**. It is important to note that each of them has its health implication above a certain limit of concentration. This has been shown in **Table 5**. For example, water with excessively high copper content causes depression, eczema, and could well affect the liver and the kidney. Research work has also implicated aluminium in the aetiology of Alzheimer's disease [51]. Fortunately, the body has a homoeostatic control over the quantity that could be assimilated from many of the metals. A good example is the strongly emetic action of copper which guards against cases of copper poisoning in man [52].

Nitrate and heavy metal trends in India

Water is a prime natural resource, a basic human need and a precious natural asset. Optimum development and efficient utilization of our water resource, therefore, assumes great significance. In most of the Asian countries the utilization of water is worked out at 85 per cent for crop, 8 per cent for industrial activities and only 7 percent for domestic purposes [53]. In the developing country such as India, bulk of population lives in remote and rural areas with no access to clean and safe drinking water. In India, over 85 percent of drinking water sources have been based on ground water aquifers. In our country the percentage of water used for various applications is 93 percent in agriculture, 4 percent in industry and only 3 percent in domestic purpose [54]. Rural population consumes water mainly for domestic and for irrigation. The Government of India initiated a National Drinking Water Mission in 1986 which has renamed as Rajiv Gandhi National Drinking Water Mission to ensure reliable and adequate drinking water supply to rural population. In addition to government provision for drinking water, the remaining rural masses largely meet its water requirement through hand pumps, open wells and animal powered implements. The demand for drinking water requirement is hampered due to irregular and erratic power supply. Indian agriculture depends on monsoon. In the eighth plan, the country has utilized 80.69 million hectares irrigation potential of which nearly 50 percent was through the ground water [55].

Table 4 Problems of Metals in Water

Metals	Problems	
	Asthetic	**Health (examples)**
Aluminium	Exacerbates iron discoloration of water	Alzhiemer's disease(not proven)
Copper	Green stains Astringent taste	Liver and kidney disease, Hepatic and renal damage, Eczema, Mucosal irritation capillary damage
Iron	Rusty stains, Brown color Turbidity, Blockage of distribution systems, Iron bacteria growth	Haemo chromatosis
Lead		Mental retardation, Anaemia, Abdominal discomfort
Manganese	Color, Black precipitate Taste, Odour, Turbidity, Stains	No effect reported
Zinc	Astringent taste opalescent	Acute renal failure, vomiting, dehydration, Nausea, muscular coordination

Table 5 Guideline values for selected chemical constituents

Constituents	Guideline Value (mg/l)	
	(a)WHO	**(b)**EC
Aluminium	0.2	0.05
Copper	1.0	3.0
Iron	0.3	0.05
Lead	0.05	0.05
Maganese	0.1	0.02
Nitrate(as N)	10	5.7(25 mg/l as NO_3)
Zinc	5.0	5.0

With the declared objectives of providing at least the basic amenities there has been a tremendous development in India, in the agriculture and industrial sector, with concomitant pressure on the fresh water resources. The waste generated by anthropogenic activities has not only polluted the environment as a whole but had a particular detrimental effect on the quality of aquatio-envison too. Leachates from compost pits, animal refuse of garbage dumping grounds nutrient enriched return irrigation flows seepage from septic tanks, seepage of sewage etc. has adversely affected the ground water quality in several parts of India. The rate of generation of wastewater in India during 1981 was estimated to be 74,529 million liters/day i.e. about 27 km^3 annually, which poses a perennial danger to the potable ground water resource. The gravity of situation can be judged from the act that in spite of sewage treatment plant, Delhi discharged 100 million gallon of untreated sewage into the Yamuna. The problem is likely to compound further with increasing rate of waste water generation which is estimated about 40 km^3 (110,000 million litre/day) annually by the year 2000 when the population is estimated to be around one million. Solid waste disposal is also not lagging behind in adding to ground water pollution problem. With increase of human and livestock population the quantum of waste produced has increased tremendously. The estimated annual waste production from these sources is around 2000 million tons. Studies on chemical composition of ground water in phrestic zone have revealed that in many cases a anomalously high concentration of nitrate potassium and even phosphate (total phosphate) are present in contrast to their virtual absence or low concentration (No. 3 and K less than 10 mg/l) in semi-confined and aquifers. Unsystematic use of synthetic fertilizers couple with improper water management practices have resulted in deterioration of ground water quality in many parts of the country [56].

Though iron content in drinking water may not affect the human system as a simple dietary overload, but in the long run prolonged accumulation of iron in the body may result in homo chromatosis, where it tissues are damaged. In some districts of Assam (Barpota, Darrang, Kamrup, Sonipni) and Orissa (Balasore, Cuttack, Puri) ground water have high iron content ranging from 1 to 10 mg/l.

According to the information available in areas of the country having high nitrate contents in the drinking waters are the Tamil Nadu, Rajasthan and the Haryana state near New Delhi [57]. The concentrations of up to 1500 mg/l have been found in ground water in agricultural areas of India (WHO 1984). Bore-well water samples of Uttar Kannada district were collected to investigate the quality of ground water. The chemical composition indicated fitness as per drinking water standards in most of the water samples, but in few water samples the nitrate concentration was found to be higher than the permissible limit [58].

Eighteen sampling stations were chosen for analysis in Bhopal. Copper is an essential component of key metalloenzyme. Zinc toxicity is due to galvanized pipes and percolation of wastes from industrial sewage. Concentration of copper is due to sewage nallah and other domestic sewage percolates in ground water. The methods in the present study were used as prescribed by APHA and NEERI [53]. The extent of marine coastal pollution along the coastal States of Orissa and West Bengal has been studied by Kumar, Bhunia and Bhattacharyya [59]. In addition to the characteristic physico-chemical background parameters, water quality was monitored in terms of heavy metals and some selected biological determinants. Spatial and temporal changes in the concentration of these parameters from inshore to offshore waters, and their possible effects on the marine coastal ecosystem have been discussed.

Colony in Vishakhapatnam draws water for domestic needs from a shallow ground water. The chemical quality of this water has been analyzed and interpreted, inferring domestic waste water, pollution and sea water intrusion into the aquifer [60]. In Uttar Pradesh review reports the application of planar layer liquid chromatography is used in the analysis of water samples for heavy metals and pesticide residues. Efforts have been made to encapsulate the literature of thin layer chromatography and paper chromatography as applied to the identification, pre-concentration, separation and quantification of heavy metals present in various water samples covering the period of last twenty years [61]. Study was conducted covering total hydrological cycle, for the determination of Fe, Mn, Zn, Cu, Cl, Pb, As and Hg in drinking water from five different sources in the Port city of Paradeep. These sources are Mahanadi water, Taladanda water, tap water, tube-well and open well water. Results showed seasonal fluctuation (**Table 6**) [62].

Table 6 Ground water pollution in India

Pllutant	**State**	**Place of occurences**
Iron	U. P.	Mirjapur
	Assam	Darrang, Jorhat, Kamrup
	Orissa	Bhubaneshwar
	Bihar	E.Champaran, Muzaffarpur, Gaya, Manger, Deoghar and Madubani
	Rajasthan	Bikaner,Alwar and Bharatpur
	Tripura	Dharmnagar, Kailasanar, Ambasa, Amarpur and Agartala
	West Bengal	Madnipur, Howrah, Hoogly and Bankura
Manganese	Orissa	Bhubneshwar, Athgaon
	U. P.	Muradabad, Basti, Rampur and Unnao
Nitrate	Bihar	Patna, E.Champaran, Palamu, Gaya, Nalanda, Nawada and Banka
	Andhra Pradesh	Vishakapatnam, East Godavri, Krishna, Prakasam, Nellor, Chittor, Anantpur, Cuddapah, Kurnool, Khaman and Nalgonda
	Delhi	Naraina, Shehadr(Blocks)
	Haryana	Ambala, Sonepat, Jind, Gurgaon, Faridabad
	Himachal Pradesh	Kulu, Solan, Una
	Karnataka	Bidar, Gulbarge and Bijapur
	M.P.	Sehore, Bhopal and (West and Central part of state)
	Maharashtra	Jalna, Beed Nanded, Latur, Osmanabad, Solapur Satara, Sangli and Kolhapur
	Punjab	Patiala, Faridkot, Firozpur, Sangrur and Bhatinda
	Rajasthan	Jaipur, Churu, Ganganagar, Bikaner, Jalore, Barmer, Bundi and

		Sawai madhopur
	Tamilnadu	Coimbatore, Penyar and Salem
	West Bengal	Uttar Dinajpur, Malda, Birbhum, Murshidabad, Nadia, Bankura and Purulia
Zinc	Andhra Pradesh	Hyderabad, Osmania University Campus
	Delhi	R.K.Puram
	Rajashan	Udaipur
Chromiun	Punjab	Ludhiana

NEERI conducted coagulation-flocculation studies on arsenic removal on water samples collected from six sources in West Bengal which are affected by arsenic. The physico-chemical characteristics of these water samples were investigated. Extensive treatability studies have shown that a dose of 3.0 mg/l of chlorine (for pre-chlorination) followed by 50 mg/l of ferric chloride was able to remove arsenic from the raw waters [63]. In some tribal areas of Satpura valley the concentration of trace metals were determined by inductively coupled plasma atomic emission spectrometer and flame photometer in well water samples. These studies aim at the assessment of the extent of ground water pollution by these metal ions. In addition to above pH, conductivity and chemical oxygen demand (COD) in all the water samples have also been detected [64].

The industries of the Patancheru and Bolaram area generate a cumulative 8 x 106 1/day of effluents which are being directly discharged on to surrounding land, irrigation fields, and surface water bodies which finally enter into the Nakkavagu River a tributary of the Manzira Rivel. Present study on abundance and distribution pattern of toxic trace elements indicates the quantitative aspect of pollution in the Nakkavagu Basin. Migration patterns drawn for TDS, toxic elements indicate that pollutants discharged by the industries are entering the surface and ground water system (aquifers) and are also migrating towards the Manzira River further deteriorating the entire hydrological setup of the area [65].

In Delhi an attempt has been made to ascertain the extent of water pollution caused due to heavy metals. Surface and subsurface water samples have been collected and analyzed for various heavy metals. In most of the samples concentration of heavy metals exceed the maximum permissible limit for drinking purpose prescribed by WHO [66]. Pushkar occupies a prominent position among the holy places of Hindus in the country. During the annual Pushkar fair about 2-3 lakh pilgrims congregate at Pushkar and take a holy dip in the Sarovar. The effects of mass bathing in the sarovar are described and remedial measures have been suggested [67].

Vast low lying alluvial tract from North-Western part of Banaskantha district through the western part of Mashing and Ahmedabad districts western and north-eastern parts of Surendranagar district, Southern part of Ahmedabad and South-Western part of Kheda district is underlain by saline ground water (EC 3.46 ds/cm). Ground water in Sangrur, Bhatinda, Ferozpur and Faridkot districts have on high as 11.30 ds/cm salinity. Ground water is saline in almost all the canal Bhakra and the lift canal system of South-Western part of Haryana. About 3766sq. km. area in Haryana is underlain by saline ground water (EC 6 ds/cm.). Arsenic in ground water has been reported in a range (0.05-3.2) mg/l in shallow aquifers from 61 blocks in 8 districts of West Bengal namely Malda, Mushirbad, Nadia, North and South 24 Pargana, Bardharnan, Howrah and Hugli [68].

The problem of drinking water remains an urgent need because only 70.5% of the urban and 8.7% of rural households have safe drinking water through piped supply and rest depends on surface and ground water which is contaminated and untreated. The approach paper to ninth plan (1997-2002) claims that 85% of urban population has access to safe water and the provision is still inadequate in slums, rural and backward areas.

Arsenic in ground water is no longer a localized problem. The latest survey has confirmed the worst fears in this regard by listing arsenic contamination in Bangladesh to be the biggest in the world. However, well-coordination action with the right sense of urgency, instead of panic, is called for in coping with this newly unfolding gigantic problem. The survey was done by the School of Environmental Studies (SOES) of Jadavpur University, Calcutta, in collaboration with the Dhaka Community Hospital.

It took four and a half years to conclude; and analyzed 22,003 tube well water samples from 64 districts and examined about 18,000 people, revealing that in 54 of the country's 64 districts arsenic in ground water is above the normal level and in 47 districts the presence of arsenic is at a dangerous level. The level of contamination is lessened at greater depth. The country became aware of arsenic contamination of ground water only in the "Nineties after use of tube well water for drinking in the villages was universalized. Experts say that the cause is geological [69].

The study of heavy metals content in drinking water of Mumbai city was undertaken recently. In the year 1998 a case study about industrial pollution was reported by Banerjee. The measurements and characterization of heavy metals in the sediment samples of Mumbai harbor Dharamtar creek and Amba River were reported. The research work has given special emphasis on contribution of petroleum hydrocarbons towards the environmental related problems [70]. Water samples at Bhopal have been analyzed for iron, lead, manganese, aluminium, copper and zinc. High concentration of toxic elements viz. iron and lead is noticed in a few samples. The probable sources for these elements are sewage and small scale industries and also highway contamination [71].

Trends of nitrate and heavy metals contamination in Rajasthan

A total of 10,6019 sq.km area (about 31%) of Rajasthan comes under saline ground water out of this 88675 sq.km area falls in western Rajasthan of Ganganagar, Barmer, Bikaner, Churu and Jaisalmer districts. The electrical conductivity of ground water in western Rajasthan is over 8 ds/cm and in eastern Rajasthan over 6 ds/cm. Proper water quality monitoring in Rajasthan has shown that nitrate occurs as major anion in the western and central parts of it. Districts like Jhunjhunu, Sikar, Churu and Barmer exhibit in 50% of samples of nitrate content in ground water more than 100 mg/l. The high nitrates in ground water of Rajasthan is due to the available sandy soil which contributes its part to the trouble with nitrates since the most substances including nitrate do not get absorbed by sand. An additional factor is higher dissolved oxygen content in the upper part of sandy soil leading among other things to the oxidation of the decomposing product NH_4^+ to the water soluble NO_3^- [72].

Jaipur, the first planned city in Northern India, now has overflowing sewerage lines, its water sources are contaminated and gardens have given way to cluttered shops and encroachments. The domestic water supply is of very poor quality. Though extensive data are not readily available there has been a steady increase in the number of people affected by cholera, typhoid and hepatitis E, all caused by contaminated water and food. Urbanization is considered as engine of growth and has positive impact in terms of production economic generation and enhanced income levels. At the same time urbanization introduced plethora of problems including as well as quality deterioration of ground water.

Singh et al. [73] in the paper" Pollution Studies on Amanishah nallah Effluents and Ground Water Sources around Industrial Belt of Southern Part of Jaipur City" have described the water quality in terms of the physico-chemical parameters in Amanishah nallah and other ground water samples. Physico-chemical pollution parameters have been analyzed to assess the water quality for the domestic and irrigation purposes. The parameters varied from station to station depending upon the quality and quantity of the effluents and sewage. An objective of the works was to highlight the pollution load with regards to the health hazardous parameters in the study area. The authors suggested Nalgonda, A.A. and Krass defluoridation methods to the population in the affected area for minimizing the excess of the parameters.

Singh et al. [74] carried out the studies on the effluent discharged from distillery industries having extremely high amounts of organic matter with dark color and foul odour. In her paper "Physico-chemical Characteristics of Distillery Effluents and its Chemical Treatment," she found that the said reason pollutes water and land when discharged untreated into water bodies and on land. The analyzed results showed that most of the parameters crossed the permissible limit. Chemical treatment by aluminium sulphate and potassium permanganate reduced color, COD, TSS and TDS. Mixture of both chemicals was found to be most effective to minimize pollutant concentration in the effluents. Maximum reduction was observed at application rate of 5g/d for color (98.3%) and COD (98.9%).

Prajapati and coworkers [75] in their paper "Physico-chemical Analyses of Groundwater of Jaipur City" reported abnormal level of nitrate in the groundwater of Jaipur which causes serious health hazards to the human. Their study showed the occurrence of high degree of nitrate in the populated areas.

Singh et al. [76] carried out the studies on "Water Pollution in Amanishah nallah and Neighboring Groundwater: Physico-chemical Studies, Effects and Remedies". According to them nitrate, EC, F^- , TDS, Cl^- , DO, BOD and other parameters were estimated and water was found to be quite nutritious except high nitrate, TH and fluoride contents.

Some of the remedial measures proposed are:

- Proper plantation around the pond should be made to avoid soil erosion through coal dump that occurs during the rainy season.

- It must be required to enact a legislation to regulate use of water resources and to prevent contamination of precious ground water in the coastal tract.

Jain et al. [77] in their paper "A General Survey and Physico-chemical Characterization of Drinking Water of Nawalgarh Town (Rajasthan)" reported a detailed study on physico-chemical analysis of eleven water samples which were collected from arid regions of Rajasthan. The studies showed that except nitrate remaining parameters are under permissible limit. Authors concluded from the obtained results that the quality of drinking water was satisfactory but improper drainage system have contributed considerable pollution to the ground water which will create health problems in future particularly due to the presence of nitrate ion. Therefore, the drainage system should be improved.

Lendhe et al. [78] in their paper "Preliminary Analyses of Soil Samples of Phirange Kharbav Lake in Relation to other Chemical Parameters" showed the fluctuations in some of the parameters like, EC, pH, organic carbon, available phosphorus and nitrates.

Murali et al. [79] presented a paper "Impact of Integrated Low Cost Sanitation on Soil – A Case Study". The soil samples were considered as indicative elements for the pollutants.

Singh et al. [80] carried out the studies on "The Removal of Pb, Ni, Fe, and Zn from the Aqueous Solution in Batch System by using Paper Mill Sludge on an Adsorbent". The results indicated that the binding of the metals taken place either through the ion exchange or physico-chemical interaction. In this study authors concluded that the adsorption of metal ions was currently of great interest as a possible convenient method for scavenging metal ions from aqueous environment which is ceaselessly being polluted.

Patel et al. [81] carried out the studies on "Removal of Color from an Aerobically Treated Textile Dyeing and Printing Wastes". The study was taken for the removal of color from textile dyeing and printing wastes due the use of KMnO4, bleaching powder and pseudomonas fluorescent bacteria and studied under the laboratory conditions. According to them KMnO4 and bleaching powder were found to be more effective in removing color than the bacteriahenerally pretreated effluents and showed easy removal of the color.

Guru et al. [82] in their paper "Subsurface Water Quality of Different Sampling Stations with Quality of Different Sampling Stations with some Selected Parameters at Machilipatanm," conducted the results of the physico-chemical parameters such as pH, EC, TDS, total hardness, nitrate and sulphate. According to them strong positive correlation (r = 1.0) was obtained between EC and TDS.

Garg et al. [83] carried out some observations on the "Heavy Metals in the Waters of a Wastewater Drain (Amanishah Nallah) Near Mansarover Region in Jaipur and Ground Water in the Vicinity". They observed that some metals like iron, copper, zinc and nickel are important for proper functioning of biological systems, whereas others are non-essential such as Pb, Cr, Cd and Al which are toxic in nature. The authors found that the water in drain near dumping site contains highest quantities of metal ions that may be due to the leaching from the solid wastes.

Chaturvedi et al. [84] in their paper "Study on Some Physico-chemical Characteristics of Flowing Water of Ganges River at Hardwar," reported the pH, DO, BOD, COD, Cl^-, NO_3, SO_4^{2-}, and TDS parameters which were found to be quite nutritious except with reference to BOD, COD and TDS.

Somashekar et al. [85] reported the high level of fluoride, total hardness and electrical conductivity. The reported work showed "Groundwater Potential and Fluoride Level in the Water of Hosadugra Taluk, Karnataka". According to them 34.76% of samples were found to contain excessive fluoride and 35.71% excessive EC and 8% excessive TH.

Subramanyam et al. [86] in their paper "A Case Study on Evaluation of Water Quality of Lakes by Pollution Index Method" showed that an accurate and rational assessment of lake water quality is required for the determining of the extent of usefulness of lake water for various uses.

Yadav et al. [87] in their paper "Geochemical Study of Fluoride in Groundwater of Behror Tehsil of Alwar" indicated that the fluoride concentration varies from 0.2 mg/L to 5.2 mg/L. The author conclusively observed that the villagers were suffering with dental and skeletal fluorosis.

Singh [88] in his paper "Quality Assessment of Surface and Subsurface Water of Damodar River Basin" concluded that the pH, BOD, COD, total alkalinity, total hardness, Pb and Hg concentrations are high as compared to the BIS standard values.

Kumar et al. [89] in their paper "Impact of Textile Industries on Groundwater Quality of Sanganer, Jaipur" reported the study taken up to assess the quality of groundwater to get an indication of contamination due to disposal of dye industry waste water and indiscriminate use of fertilizers with a view that the study would serve a base to evolve suitable waste management strategy for the area.

Anjaneyulu et al. [90] carried out studies on an application of mixed adsorbent (oxygenated coconut shell, activated carbon and clay) for removal of basic dyes from industrial effluents. Detailed batch studies revealed that the maximum removal of dyes can be achieved with mixed adsorbents.

Kiran et al. [91] in their paper "Wetland Inventory and Monitoring using Geographical Information System presented at Training Workshop on Wetland Research Methodology: Measuring and Monitoring Biodiversity" indicated that the deficiency in proper management of non-point sources of pollution like storm water, agricultural runoff, and unregulated land use management have led to the steady increase in problems of pollution, eutrophication, invasion of exotic species, toxic contamination by heavy metals, pesticides and organic compounds.

Ajali et al. [92] discussed "Physico-chemical Studies of Drinking Water of Durg Municipality". The samples of raw water and treated water were collected from utility points (Municipal tops). They were reported higher values for the chemical parameters. The TDS concentrations at these places were above the limit (500 mg/L). The total hardness was also found to be higher. The fluoride content was found to be much lower than 0.5 mg/L and hence there was a deficiency in fluoride.

Ince et al. [93] discussed about the treated ability of textile dye-bath effluents by advanced oxidation with fenton and fenton like reagents, in the presence and absence of UV light, using a reactive azo-dye (Procin Red HE7B), and typical dye bath constituents. In a paper "Treatability of Textile Dye-Bath Effluents by Advanced oxidation: Preparation for Reuse," they reported the complete color removal and 79% total organic carbon degradation by this method.

Singer et al. [94] in their paper "Soils: An Introduction," explained that the level of forest soil acidification is largely based, in addition to pH, upon the factors of soil type, soil sensitivity and precipitation. Chemically, acid can catalyze or hinder many important chemical soil processes. Acid forest soils often develop high levels of soluble aluminium. The prime sources of pollution are domestic and industrial sewage as point sources besides agricultural run-off and the more insidious atmospheric pollution contributing to the non-point sources. Pollution studies suggested that 70% of 31,00 cities and towns (Population 7100,000) in India have no sewage treatment facilities[90].

Increased salinity has led to the accumulation of salts in surface as well as in ground water was suggested by Jacks and coworkers [95].

The authors have pointed out that the discharge of chemicals in Triuppur Town makes the groundwater and surface water unsuitable for the irrigation and domestic uses. The high salts concentration and the dominant sodium ions rendered it unsuitable for irrigation due to the exchange of Na^+ ion in the soil zone, with Cd^{+2} ion during the percolation of industrial effluents.

The water released from the dam damages the agricultural yield and makes the crops wither and die. The ground water quality in its vicinity has resulted in the damage of the agricultural crops and caused skin disease, in those who used the groundwater for bathing was reported by Padnamabhan [96]. He also reported that the groundwater resources are gradually depleting in Tiruppur because of continuous pumping. The contamination of the well water and surface water is due to the indiscriminate discharged of effluents from dyeing and bleaching industries.

Akinbiyi [97] is of the opinion that over the years there have been a considerable growth in the awareness of environmental pollution problems and it has become a major national and international political issue. According to him most populous cities in sub-samara tropical Africa is experiencing the problem of municipal waste management, principally as a result of unplanned development, rural-urban migration and natural increase within city.

Conclusion

The authors concluded from their work that the water samples need constant monitoring of various water sources as the results showed levels of pollution higher and unfit for drinking and other purposes. People may suffer through disease on drinking water with higher concentration of heavy metals. They may have physiological effects as on kidney, digestive system, circulatory system, nervous system etc. various other organs and various systems of the body. Groundwater from a rural region in Rajasthan and other countries was analyzed along multiple geochemical dimensions to identify main sources and transformation processes of nitrate and heavy metals in groundwater. More research is needed to assess the extent to which these products affect human health. Public awareness should be created. There should be monitoring and control over the concentration of nitrates and heavy metals in groundwater for healthy future.

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