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Review Article

TRACE ELEMENT IN GROUND WATER WITH SPECIAL REFERENCE TO BAREILLY DISTRICT OF U.P. INDIA

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ABSTRACT
This review assessed the related published information on groundwater quality in Bareilly district. Firstly, the range of relevant groundwater quality issues including trace elements contaminants in groundwater dependent ecosystems; and groundwater-surface water interactions and suggested the management implications. The information on various groundwater quality issues provided in this report has been solicited mainly through publicly available web sources.

KEYWORDS: groundwater, quality, management implications.

INTRODUCTION

Ground water is the primary source of water for meeting the requirements of various sectors. It also plays a vital role in India's economic development and in ensuring its food security. The reports of Central Ground Water Board, Faridabad 2010 shows that the ground water is potable and suitable for various uses but ground water also has various chemical constituents in excess beyond the limits of drinking water standards in almost all the states of India. The commonly observed contaminants are arsenic, fluoride and iron which are geogenic, whereas contaminants such as nitrates, phosphates, heavy metals *etc*. originate from various human activities such as domestic sewerage, agricultural practices and industrial effluents. The ground water quality is deteriorating due to geogenic and anthropogenic activities. Several studies have been conducted on the groundwater contamination through trace elements. Khan *et al*., 2010 worked on the sources of trace elements in ground water of Hindon -Yamuna Region, Baghpat District, western Uttar Pradesh and found that some elements like Fe, Mn, Sr, Cr, Al and Pb are concentrated above the permissible limit in groundwater of investigation area. The concentration of these elements in the groundwater is increasing mainly from industrial effluents of sugar mills, pulp and paper factories, cooperative distilleries and municipal wastewater.

In 2012 Senthil Nathan studied the trace elements in groundwater of Coastal Aquifers of Pondicherry Region, India and it was found that the concentrations of arsenic and iron were higher than the permissible limits of World Health Organization. In 2009 Jha and Tignath studied the impacts of surface water environment in and around Jabalpur city, Madhya Pradesh and determined that the water is fit for agricultural purposes.

Recently, Yadav and Augar 2015 assessed the ground water of Takhatpur region in the Bilaspur District and found that the concentration of iron was more than the maximum contaminant level (MCL) in 46.5% of the samples and also recommended that an adequate and suitable treatment must be applied to the wells.

The management of groundwater pollution has become need of the hour, because of the harmful impacts on human health. Many naturally occurring major, minor trace elements in drinking water may have significant effects on human and animal health either through its deficiency or through excessive intake (Frengstad *et al*., 2001). Several studies have been carried out on trace elements in groundwater of the Ganga basin. Khan and Khurshid 2015 studied the trace elements (Al, Cd, Co, Cr, Fe, Mn, Ni, Pb, Zn) of ground water quality of Aligarh city UP and found the high concentration of Al, Fe, Mn, Zn and Pb in most analyzed samples. These high concentrations of metal ions in groundwater were probably due to discharge of untreated effluents from various industries such as lock and hardware industries, metal casting industries.

Abdul rahman *et al*., 2011 assessed trace metals in ground water used for drinking purposes in Riyadh region in the kingdom of Saudi Arabia and found that the concentration of Fe, Mn, Al, Se, Ba and Hg were exceeded maximum contaminant level (MCL) and recommended an adequate and suitable treatment to the wells before supplying drinking water to the consumers. Sandeep (2012) studied the biological effect of heavy metals in drinking water samples of Western Uttar Pradesh region in India and concluded that certain health problems of people are due to presence of excess of heavy metals and other impurities.

In Bareilly District, Systematic hydro geological survey was first carried out by Shri M.L. Srivastava and Shri D.L. Shah, Junior Hydrogeologist CGWB / GSI in 1973-74 and 1960-61 respectively. In the year 2000-2001 reappraisal surveys were carried out by Shri R.K. Rajput, Assistant Hydrogeologist. Assessment of diverse resources of ground water quality in Bareilly district (U.P.) was carried out in 2013 (Rizvi *et al*., 2013).

Definitions of Trace Elements

Trace elements are known by different names such as potentially toxic elements, trace metals, heavy metals, micro nutrients, and minor elements. The term "potentially toxic elements" is a recent term, illustrate that while some elements are toxic to humans and plants, not all elements are toxic at all concentrations. Some elements (*e.g.,* Fe) are necessary for life in small amounts (Alloway, 1995).

Trace elements have different definitions, for example, for a chemist, trace element or transition metals are those elements which fall in the centre of the periodic table (between Group IIA and IIIA) and exhibit partial d-orbital filling. Other chemical definitions are based on density (greater than 5 g/cm^3), atomic weight (greater than that of sodium) and metallic properties.

For a Geologist, trace elements are the elements in rocks other than the most abundant eight elements found in the Earth's crust. For a Pedologist, trace elements are essential for plant growth in small amounts, but toxic to plants at higher concentrations. For a Toxicologist, trace elements are distributed into the environment by industrial processes that are detrimental to human health or the environment.

The widespread trace element contamination is caused by industrial processing. The manufacturing of many goods requires the use of trace elements such as Fe, Al, Cu, Pb, Cd, Ni, Hg, As, and Se, so these elements have become common in industrial wastes and in some cases end up in the environment. The Resource Conservation and Recovery Act (RCRA), enforced by the United States Environmental Protection Agency (EPA) has set mandatory cleanup guidelines for these trace elements: Ag, As, Ba, Cd, Cr, Hg, Pb, and Se. These eight trace elements are commonly known as the RCRA metals.

Trace Elements in Soil

In soil, trace elements are derived from the weathering of geologic parent materials and tend to be immobile. (Adriano 1986, Middelburg *et al*., 1988). Plant uptake and nutrient cycling transport the trace elements in A horizon.

According to soil scientists, trace elements in soils are generally insoluble and exhibit strong adsorption. Concentrations of trace in soil are important to soil scientists not only for environmental purposes, such as quantifying contamination, but also to help solve problems associated with human and plant toxicity. The most studied elements are Ag, Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, P, Pb, Sb, Se, Si, Sr, Th, Ti, V, and Zn. (Holmgren *et al*., 1993, Shacklette and Boerngen 1994).These elements are usually described in terms of their total content and availability. In soil, trace element retention is dependent on parent material and several soil characteristics such as pH, cation exchange capacity (CEC), particle size distribution, organic matter content, and oxide content. These characteristics cause trace elements to either accumulate in the soil or leave the soil for other components of the environment.

Trace Elements in Geologic Materials

Parent material is the original source of trace elements in soils. Trace elements are present in many minerals and ore deposits that make up different rocks and geologic units. Rocks vary widely in trace element content but generally, certain rocks are higher and lower. The following table (adapted from Kabata-Pendias and Adriano, 1995) shows commonly reported values for trace elements in igneous and metamorphic rocks.

TABLE 1- Concentration of trace elements in igneous and metamorphic rocks

ROCK TYPE			
ELEMENT	FELSIC (mg/kg)	INTERMEDIATE (mg/kg)	MAFIC (mg/kg)
V	40 - 90	30 - 100	200 - 250
Cr	04 - 25	15 - 50	170 - 200
Mn	350 - 600	500 - 1200	1200 - 2000
Co	01 - 07	01 – 10	35 - 50
Ni	05 – 15	05 – 55	130 - 160
Cu	15 – 30	15 – 80	60 - 120
Zn	40 - 60	40 - 100	80 - 120
As	01 - 2.6	01 -2.5	0.6 - 02
Cd	0.09 - 0.2	0.13 - 0.13	0.13 - 0.22
Ba	400 - 850	600 - 1000	250 - 400
Hg	0.08 - 0.08	BDL	BDL
Pb	15 -25	12 - 15	03-08
U	2.5 - 06	1.4 - 03	0.3 - 01

BDL - Below detection limits

Trace element concentrations in rocks are dependent on the trace element concentrations of the rock forming minerals. The following table (adapted from Smith and Huyck, 1999) shows trace elements found in the major rock forming minerals.

Trace Elements in Ground Water

Trace elements in groundwater depend on the source of ground water and the bio-geochemical process in elemental conditions (WHO, 1993). Groundwater is a vast and slow moving resource that greatly exceeds the volume of other available freshwater sources. Aquifers are composed of permeable materials and capable of storing and yielding large quantities of water. Aquifers also consist of gravel, sand, sandstone or fractured rocks.

The major factor affecting trace-element occurrence includes geologic composition of aquifers and aquifer geochemistry. Trace-element concentrations in groundwater were characterized in aquifers from eight major groups based on geologic material, including (1) unconsolidated sand and gravel; (2) glacial unconsolidated sand and gravel; (3)semi consolidated sand; (4) sandstone; (5) sandstone and carbonate rock; (6) carbonate rock; (7) basaltic and other volcanic rock; and (8) crystalline rock (Ayotte *et al*., 2011). Ayotte 2011 also reported that climate influences the occurrence and distribution of trace elements in groundwater. More trace elements were found at greater concentrations in wells in drier regions of the United States than in humid regions.

Trace elements are distributed in groundwater from a variety of natural and anthropogenic sources (Mondal *et al*., 2010). Landfills have been identified as one of the major threats to groundwater resources. The areas near landfills have a greater possibility of groundwater contamination because of the potential pollution source of leachates originating from the nearby site (Nixon *et al*., 1997, Aldecy de Almeida and Shozo, 2008). Such contamination of groundwater resource poses a substantial risk to local resource user and to the natural environment (Mor *et al*., 2006).

Groundwater and Surface Water Interaction

Groundwater and surface water are fundamentally interconnected in the hydrologic system. In fact it is often difficult to separate the two because they feed each other. This is why one can contaminate the other. Thus, an understanding of the basic principles of interactions between groundwater and surface water is needed for effective management of water resources.

FACTORS INFLUENCING GROUND WATER QUALITY

Borehole depth

The groundwater quality depends on boreholes depth, permeability of sediments and type of sediments through which groundwater moves, climatic variations and anthropogenic activities among other things (Harrison, 1996). The depth of groundwater has therefore important implications on water quality. The water levels in an aquifer may also fluctuate during the year as a result of seasonal rainfall or drought. If the use of ground water exceeds recharge over long-term, the water level may decline over time.

Alkaline earth metals in aquifer

Alkaline earth metals are barium, calcium, magnesium and strontium. They belong to the same chemical group but vary widely in their abundance and behavior in groundwater. Calcium and magnesium are abundant in rocks and soil particularly in limestone and dolomites and are also relatively soluble. Barium and strontium compounds are less soluble than those of calcium and magnesium.

Ground water contamination

Contamination of groundwater may be associated with specific point sources or may occur over a wide area (non-point source). The sources of groundwater contamination are improper disposal, use and storage of chemicals; poor installation and maintenance of septic tanks; landfills; leaking or poorly located storage lagoons used by industries, farms, mining operations, oil and gas producers; excessive use of fertilizers and pesticides; land application of sludge and wastewater or urban runoff. Contaminants can be extremely hard to remediate with pollution often resulting in permanent damage to the aquifer. Great improvements in groundwater pollution prevention have occurred in the last few decades but diffuse source contamination (for example, pesticides, fertilizers, and septic tanks) remains poorly controlled in some jurisdictions (Harris *et al*., 2006).

TRACE ELEMENTS IN PLANT AND ANIMAL NUTRITION

Trace elements were studied by scientist for their effect on plant nutrition and toxicity. A majority of the research was conducted in the 1950's and 1960's on the trace elements which is essential for normal plant growth and function (Tisdale *et al*., 1993). Macro nutrients (those nutrients needed in large amounts by all plants) include C, H, O, N, P, K, S, Ca, and Mg, although C, H, and O are not usually considered mineral nutrients (Tisdale *et al*., 1993).

Micro nutrients (those nutrients needed by all plants in relatively smaller amounts) include Fe, Zn, Mn, Cu, B, Cl, and Mo (Tisdale *et al*., 1993). In addition, some micronutrients are needed by only certain plants, include Na, Co, V, Ni, and Si (Tisdale *et al*., 1993).

Trace elements and their influence on human health and living organisms

Trace elements are natural components and cannot be degraded or destroyed. It enters the human body through drinking water, food or air. In small amounts, some of these trace elements are essential to maintain the metabolism of the human body, but in higher concentrations they can lead to poisoning. Trace elements are dangerous because they bio accumulate, which means that they increase in the concentration in a biological organism over time. The accumulation occurs in the organism when the trace element is taken up and stored faster than they are broken down. Worldwide studies have shown that high concentrations of trace elements can have adverse effects on human health (Wasserman *et al*., 2006; Meliker *et al*., 2007; Walker *et al*., 2008). Jinwal *et al*., 2009 evaluated that trace metals like Fe, Mn, Cu, Zn, Co, and Ni are micro nutrient for living system, their deficiency or excess can lead to a number of disorder in human body. Some trace metals like Cd, Pb and Cr can be lethal to human being even at low concentration because of their tendency to accumulate in the body (Khan *et al*., 2010).

In 2013 Birsinghpur Area, Satna district, Madhya Pradesh, India, the study reveals that excessive concentrations of trace elements in ground water are due to combined effects of geogenic sources as well as of mining activities and excessive use of chemical fertilizers. It is recommended to control anthropogenic activities adequately in order to minimize the pollution problems. (Tiwari *et al*., 2013)

The following part deals with trace elements, essential in the context of this review.

Arsenic

Naturally arsenic exists as ores and can be concentrated in sulphide bearing minerals, such as arsenopyrite (FeAsS.) Arsenic enters the environment through natural and anthropogenic processes. Dubey *et al*. (2012) showed that arsenic contamination in ground water of Delhi is due to the anthropogenic activities. Human activities such as mining and metallurgy, wood preservation and thermal power plants using coal are typical examples that release as in the environment and are processes. This contributes to both atmospheric and terrestrial depositions (Bhattacharya *et al*., 2002). Arsenic is found in four oxidation states –III, 0, III and V. Arsenic is essential for life in small amounts but in its inorganic form As (III) and As (V) arsenate, is toxic for plants, animals and humans. Inorganic As is a documented human carcinogen. The World Health Organization (WHO) has adopted provisional guideline values for as in drinking water is 0.01 mg/l.

Iron

In nature Iron (Fe) is most commonly occurs in oxides and rarely in its elementary forms Fe (II) and Fe (III). Drinking water containing 0.3 mg/l Fe may affect the taste. No health-based guideline value is established. According to WHO 2004 Maximum Tolerable Daily Intake (PMTDI) value of Fe in drinking water which does not pose any health hazard is 2 mg/l. A study was conducted in Haier Region of Saudi Arabia and found that iron (Fe) showed a presence of almost 140% higher than the maximum permitted levels according to EPA and WHO for all collected water samples (Qindeel *et al*., 2015).

Manganese

Manganese is one of the most abundant elements in the earth's crust and is often coexist with Fe. Mn exists in three different oxidation states, Mn (II), Mn (IV) and Mn (VII), where the Mn (II) is the most common form in surface water with pH between 4 and 7. At higher pH the more oxidizing forms may be present. The occurrence of manganese in aerated water is often a result of industrial pollution. Concerning oral intake, Mn is often regarded as one of the least toxic elements, but different studies has shown that there is a relation between high intakes of Mn and neurological effects. In drinking water, concentrations of Mn exceeding 0.1 mg/l, gives the water an undesirable taste. WHO has decided a health-based guideline value of 0.4 mg/l (WHO 2004). Shekhar and Sarkar 2013 studied the ground water of Najafgarh drain of Delhi and found that in about 23% of the samples, manganese concentration was beyond the prescribed limit for drinking water of 0.3 mg/litre (BIS 1991).

Aluminium

In natural water at high and low pH levels, Al has an increased solubility (Stoeppler 1992). This is one of the major problems with acidification, since Al is toxic for living organisms (Gustafsson et al. 2006). In several studies, a relation between neurological diseases and elevated levels of Al in the tissues has been discovered. A correlation between Al and Alzheimer's disease has been discovered since the brains of Alzheimer patients appear to have elevated levels of Al in the grey matter.

Cadmium

Environmental pollution of cadmium (Cd) is often related to smelters of Pb, copper (Cu) and Zn and can affect humans living in surrounding area of these. Human exposure of Cd is otherwise rare (Selander & Svan *et al*., 2007). In natural water, most of the Cd is bound to the sediments and when more acid conditions occur it may be dissolved. Cadmium is one of the most toxic metals. It has been revealed that exposure of Cd significantly elevates the risk of getting cancer in the kidneys. In greater concentrations Cd can also counteract the uptake of calcium in bones, which may lead to softening of the skeleton (Selander & Svan *et al*., 2007). WHO has established a guideline value of Cd in drinking water of 0.003 mg/l (WHO 2004).

Zinc

Zinc always occurs in small amounts in igneous rocks and is most commonly present as sulfides in ores. Drinking water can contain substantially higher levels of Zn than that due to leaching of Zn in pipes and fittings. In natural waters, an extensive amount of Zn is bound to organic complexes (Lilja&Linde *et al*., 2006). Zinc is an essential nutrient for human beings and its deficiency causes many diseases. On the other hand, a high level of Zn in the body is related to Cu deficiency. Zinc in toxic doses may cause fever, nausea, vomiting and stomach cramps (WHO 2004). WHO has not developed a guideline value of Zn in drinking water but the Bolivian limit is 20 μg/l (Selander&Svan *et al*., 2007).

Nickel

Generally concentration of Ni in drinking water is below 20 μg/l but significantly higher concentrations up to 1000 mg/l have been detected as a consequence of natural or industrial nickel deposit affecting raw waters or as a result of leaching from taps and fittings. For humans, the adsorption of Ni is 40 times higher when intake is through drinking-water than from food. Nickel poisoning is rare but cases have been reported with symptoms like nausea, vomiting, abdominal discomfort and shortness of breath *etc*. The WHO has established a provisional guideline value for Ni in drinking water of 0.02 mg/l (WHO 2004).

Lead

In earth's crust Galena (PbS) is the main mineral from which Pb is obtained. Lead contamination in the environment is mainly due to anthropogenic activities. Smelters emit about five times more Pb than natural sources (Lilja & Linde *et al*., 2006. Lead is a cumulative general poison, affecting the central nervous system. The WHO provisional guideline value of Pb in drinking water is 0.01 mg/l.

Chromium

In surface water the chromium (Cr) exists in two predominant oxidation states *i.e.* Cr (III) and Cr (VI). Chromium (VI) salts are more soluble, making it more mobile and toxic than Cr (III). The high concentration of Cr in surface water is due to the industrial pollution. International Agency for Research on Cancer (IARC) has classified Cr (VI) in Group 1 human carcinogen). According to WHO 2004 the health-based guideline value of Cr in drinking water of 0.05 mg/l is based on the total Cr.

TABLE 2: Range of Concentration of Trace Elements in Groundwater According to BIS (1991) and WHO (1994) Drinking Water Standards

Constituents	BIS (1991) (mg/l)		WHO (1994) (mg/l)	
	Highest Desirable Level	Maximum permissible Level	Highest Desirable Level	Maximum Permissible Level
Copper	0.05	1.5	0.05	15
Iron	0.3	1	0.1	1
Lead	0.1			0.1
Manganese	0.1	0.5	0.05	0.5
Cadmium	0.01	0.01		0.01
Nickel	0.1	0.3		
Cobalt				
Chromium	0.05	0.05		
Zinc	0.1	15	5	15
Selenium	0.01	0.1		
Aluminum	0.03	0.2		
Boron				0.3
Arsenic				0.01

Some elements are essential, in low concentrations, for proper metabolism in all living organisms, yet toxic at high concentrations; other elements currently thought of as non-essential are toxic even at relatively low concentrations.

Other Contaminants

Organic and inorganic contaminants are sometimes inadvertently released to the groundwater by many activities like manufacturing, transport, storage and waste disposal. The extent of groundwater contamination by industrial chemicals is very limited. Some of the available information is presented below.

In Western Australia, leaking of underground storage tanks at petrol stations is a widespread threat to groundwater, due to their large number and distribution (EPA WA, 2007). Undetected prolonged leaking of petrol contaminates the ground water which may affect drinking water supplies, residential or production bores, and eventually wetlands and waterways.

In New South Wales NSW, industries are responsible for the groundwater contamination and occurs at about 90 of the currently regulated sites (DEC NSW, 2006). The sources of contamination are distributed between purpose-built hydrocarbon storage sites such as service stations and depots (30%), industrial sites (38%), and landfills, gasworks and other land uses (32%).

Ground Water Scenario in Bareilly Region

Many studies have investigated the concentrations of other parameters in groundwater. A study done by (Gangwar *et al*., 2013) reported that Bareilly Nagar Nigam takes supply of water from underground storage. On Assessment of parameters like pH, TDS, Calcium Hardness, Magnesium Hardness, Total Hardness, Alkalinity and the results come out of study shows that the water is fit for consumption and the tap water supply is good due to the treatment of water before supply.

Groundwater contains a variety of chemical constituents at different concentrations. A much smaller part has its origin in the atmosphere and surface water bodies. In most ground waters, 95% of the ions contains the positively charged cations sodium (Na+), potassium (K+), calcium (Ca2+) and magnesium (Mg2+), and the negatively charged anions chloride (Cl-), sulfate (SO42-), bicarbonate (HCO3-) and nitrate (NO3-). These ionic species causes salinity that is commonly referred to as total mineralization or total dissolved solids (TDS).

The hydro geochemistry may be used effectively to derive parameters such as recharge, discharge and mixing rates. Any changes in the groundwater chemistry can be used to track the movement of water, water residence time in the saturated zone, identifying recharge processes and the source of recharge water.

Ground Water as a Resource

Being close to the Himalayas, Bareilly district has vast water resource to be utilized for its agriculture needs. Irrigation mostly depends on the ground water resource due to its assured and timely supply but it's over exploitation adversely affecting its regime for a better ground water management. It is necessary to have a constant vigil on its overall reserve and status of utilization.

Depth to Water Level

Depth to water level of topmost ground water saturated surface is unconfined aquifer. CGWB and State Ground Water Department, U.P., have analyzed the ground water regime & its behavior in the district during pre monsoon (June, 2007) and post monsoon (Nov, 2007), the water level and fluctuation data of permanent hydrograph stations. It is indicated that water level in Bareilly district varies between 0and 7mbgl. However, in the southwestern parts deeper water levels upto 15 mbgl or more are observed. Along the Ramganga river water levels are shallower and with in 5mbgl.

Ground Water Quality

Generally, the ground water quality in phreatic aquifer (dug well /shallow tube well zone) is colorless, odourless and slightly alkaline in nature. According to ground water brochure of district Bareilly, U.P, R.K. Rajput the specific electrical conductance in phreatic zone water ranges from 350-1610 µs/cm at 25^{0}C. In 63% of analyzed water samples conductance was below 750 µs/cm at 25°C has been observed. It is observed that the ground water is suitable for drinking and domestic use in respect to all constituents except Nitrate. The high concentration of Nitrate is found in Bhojipura (205 mg/l) and Ranman area (125 mg/l). The value of Nitrate ranges from ND to 205 mg/l. Excessive use of fertilizers in agriculture fields and improper waste disposal is the cause of high nitrogen content. The Arsenic content ranges from

0.001 to 0.034 ppm (Dhanali east) in the ground water of the district.

Ground water Quality Protection and Management

Groundwater quality protection in Bareilly varies from area to area and is generally inconsistent and uncoordinated. However, there are a variety of strategies that have been implemented to protect groundwater quality. Some of the strategies are discussed below.

Bore Construction Considerations

Water agencies in each of the state and territories have responsibility for the management of groundwater resources. The owner or legal occupier of the land on which a bore is to be constructed must obtain the appropriate license or permit from the licensing authority in the relevant state or territory. After the bore has been constructed, the driller must provide the drilling logs, construction details of the bore and decommissioning report to the state and territory water agencies.

Tools for Groundwater Quality Protection

Jurisdictions have developed a number of tools to protect groundwater quality. The tools include groundwater vulnerability maps, beneficial use maps, wellhead protection plans, groundwater management plans, and education and community awareness programs. The tools are valuable resources that should be used by groundwater managers, planners, developers, and regulatory agencies to make better informed judgments on where to locate potentially polluting activities so as to minimize the risk to groundwater.

Groundwater Vulnerability Mapping

Groundwater vulnerability mapping is used as a guide in determining the susceptible areas of groundwater contamination. Groundwater vulnerability maps are prepared by simplification of complex geologic and hydro geologic characteristics of a particular site using a rating index approach. The parameters in the development of a groundwater vulnerability map included: depth to water table, recharge, aquifer media, soil media, topography, and impact of Vadose Zone. Three classes of vulnerability ranking have been normally chosen to describe the relative assessment of the probability of a groundwater resource to contamination: low, medium and high.

Groundwater Quality Monitoring and Guidelines

Groundwater quality monitoring is very important for groundwater resource management programs. Groundwater quality monitoring is defined as an integrated activity for obtaining and evaluating information on the physical, chemical, and biological characteristics of ground water in relation to human health, aquifer conditions, ecosystem health, and designated ground and surface water uses. Ideally, groundwater quality monitoring should be carried out on a regular basis where groundwater is being extracted for a variety of uses. It should be an integral aspect of groundwater management. In states and territories agencies are responsible for groundwater quality monitoring. Quite often it is the Environmental Protection Agencies (EPA) that undertakes monitoring, but sometimes the Water departments have this role. Among the various water quality parameters, electrical conductivity (EC) is one of the most important and commonly measured parameters in groundwater. Other parameters such as nutrients, pesticides, trace elements and acidity are measured less frequently or not measured. The frequency of groundwater quality sample collection, the sampling methods, the number of sites sampled and the groundwater quality parameters measured, vary between the states and territories.

National water quality guidelines place specific constraints on the quality of water that is intended for specific uses.

Many states and territories have used the national groundwater guidelines to develop groundwater policy and regulations designed to improve the management of groundwater resources. A broad range of measures are currently implemented across all jurisdictions to protect groundwater water quality. Some of the national and state-wide policies and programs that are implemented are discussed below.

National Policies and Programs

National Water Quality Management Strategy (NWQMS):

It provides national policies, guidelines, information and tools to help government and communities manage water resources to meet current and future needs. It includes 24 nationally endorsed, non-mandatory guideline documents covering topics such as water quality management and monitoring, the treatment and management of sewage and groundwater protection.

Guidelines for Groundwater Quality Protection

It Provide a national framework for protecting groundwater from contamination. Many jurisdictions have used the Groundwater Guidelines to develop groundwater policy and regulations designed to improve the management of groundwater resources.

State-Wide Policies and Programs

At state and territory level various policies and programs have been implemented that provide a framework for improving groundwater quality across the state. In general all states and territories have implemented the key elements of the groundwater quality protection guidelines. The groundwater protection strategies are set out in three frameworks.

Groundwater Management Framework

It comprises legislation, regulation and policy about water management plans, allocation, bores, and public water supply;

Environment Protection Framework

It comprises legislation, regulation and policy about waste management, environmental assessment, agricultural chemicals, dangerous goods, and environment protection in the resources industries.

Land-Use Planning Framework

It comprises legislation, regulation and policy about land use and development, and in some cases, land clearing. Further details on the States legislation, regulation and policy on groundwater protection can be accessed from a regulatory review report (Nelson, 2009).

Ground Water Management Strategies in Bareilly

Ground Water Development

As per ground water resources available in the district, Riccha, Baheri, Bhojipura, Bithrichainpur, Faridpur and Kiyara blocks fall in the 'Safe' category, where ground water development stage is upto 89%. The remaining blocks are categorized as semi critical to over exploited, where further development of ground water should be regulated or restricted. However, tube wells below 200m may be constructed tapping deeper aquifers.

Water Conservation & Artificial Recharge

The Alampur Zafrabad block is categorised as over exploited block where artificial recharge structures and rain water harvesting schemes are to be implemented using surplus rain water. The technical guidance regarding artificial and rain water harvesting schemes are provided by Central Ground Water Board as and when required.

Awareness and Training Activity

Three mass awareness programmes have been carried out by Central Ground Water Board in Bareilly district; at Shyamganj, Bareilly, CGWB, division-XVI office and at Civil Lines in Bareilly.

Presentation and Lecture Delivered in Public Forum / Radio / TV / Institution of Repute / Grass Root Associations / NGO / Academic Institution Etc.

Time to time, the programs on water are broadcasted by television and radio through national & regional agencies of Government of India.

CONCLUSION

This review provides a summary of previous studies that has been undertaken to assess the current and emerging groundwater quality issues in Bareilly District. The review considered a range of groundwater quality issues and management implications. In states and territories agencies are responsible for groundwater quality monitoring. Quite often it is the Environmental Protection Agencies (EPA) that undertakes monitoring, but sometimes the Water departments have this role. The pollution of ground water is as a result of anthropogenic activities. The pollution levels in these water bodies should be checked to keep away water born diseases and out break of epidemics. The frequency of groundwater quality sample collection, the sampling methods, the number of site sampled and the groundwater quality parameters measured vary between the states and territories. There is no consistent program on groundwater quality monitoring in Bareilly to provide a national picture. Much of the groundwater quality monitoring has been short term and non-ongoing and it is difficult to ascertain clear long-term trends. Thus it is the need of the hour to regular monitoring and proper management of ground water quality.

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