GROUND WATER QUALITY FEATURES OF THE COUNTRY

Introduction

Ground water is an essential and vital component of our life support system. The ground water resources are being utilized for drinking, irrigation and industrial purposes. There is growing concern on deterioration of ground water quality due to geogenic and anthropogenic activities.

The quality of ground water has undergone a change to an extent that the use of such water could be hazardous. Increase in overall salinity of the ground water and/or presence of high concentrations of fluoride, nitrate, iron, arsenic, total hardness and few toxic metal ions have been noticed in large areas in several states of India.

Ground water contains wide varieties of dissolved inorganic chemical constituents in various concentrations as a result of chemical and biochemical interactions between water and the geological materials through which it flows and to a lesser extent because of contribution from the atmosphere and surface water bodies.

Ground Water Quality in India

Ground water in shallow aquifers is generally suitable for use for different purposes and is mainly of Calcium bicarbonate and mixed type. However, other types of water are also available including Sodium-Chloride water. The quality in deeper aquifers also varies from place to place is generally found suitable for common uses. Only in some cases, ground water has been found unsuitable for specific use due to various contaminations mainly because of geogenic reasons. The main ground water quality problems in India are as follows.

Inland Salinity

Inland salinity in ground water is prevalent mainly in the arid and semi arid regions of Rajasthan, Haryana, Punjab and Gujarat and to a lesser extent in Uttar Pradesh, Delhi, Madhya Pradesh Maharashtra, Karnataka , Bihar and Tamil Nadu. About 2 lakh sq.km area has been estimated to be affected by saline water of Electrical Conductivity in excess of 4000 μS/cm. There are several places in Rajasthan and southern Haryana where EC values of ground water is greater than 10000 μS /cm making water non-potable.

Inland salinity is also caused due to practice of surface water irrigation without consideration of ground water status. The gradual rise of ground water levels with time has resulted in water logging and heavy evaporation in semi arid regions lead to salinity problem in command areas. As per recent assessment about 2.46 m ha of the area under surface water irrigation projects is water logged or threatened by water logging.

Coastal Salinity

Coastal areas represent zones where land and sea meet and comprises variety of complex environments including deltas, estuaries, bays, marshes, dunes and beaches. Coastal aquifers have boundaries in contact with seawater and are always under dynamic equilibrium with it. Withdrawal of fresh ground water from these aquifers may result in inequilibrium resulting in intrusion of saline water in coastal aquifers.

The Indian subcontinent has a dynamic coast line of about 7500 km length. It stretches from Rann of Kutch in Gujarat to Konkan and Malabar coast to Kanyakumari in the south to northwards along the Coromandal coast to Sunderbans in West Bengal .The western coast is charactrised by wide continental shelf and is marked by backwaters and mud flats while the eastern coast has a narrow continental shelf and is characterized by deltaic and estuarine land forms. Ground water in coastal areas occurs under unconfined to confined conditions in a wide range of unconsolidated and consolidated formations.

Normally, saline water bodies owe their origin to entrapped sea water (connate water), sea water ingress, leachates from navigation canals constructed along the coast, leachates from salt pans etc. In general, the following situations are encountered in coastal areas

i. Saline water overlying fresh water aquifer
ii. Fresh water overlying saline water
iii. Alternating sequence of fresh water and saline water aquifers

In India, salinity problems have been observed in a number of places in coastal areas of the country. Problem of salinity ingress has been noticed in Minjur area of Tamil Nadu and Mangrol – Chorwad- Porbander belt along the Saurashtra coast. In Orissa in an 8-10 km. wide belt of Subarnrekha, Salandi, Brahamani outfall regions in the proximity of the coast, the upper aquifers contain saline horizons decreasing landwards. Salinity ingress is also reported in Pondicherry region, east of Neyveli Lignite Mines.
Some of the options available for removal of salinity from drinking water are –

i) Electrodialysis
ii) Reverse Osmosis
iii) Ion exchange

Fluoride

Fluorine is the lightest member of the halogen group of elements. Fluorite (CaF2) is a common fluoride mineral. This mineral has a rather low solubility and occurs in both igneous and sedimentary rocks. Apatite (Ca_5 (Cl, F, OH) ($PO_4)_3$,) commonly contains fluoride. Most fluorides are sparingly soluble and are present in natural water in small amounts.

High concentration of fluoride in ground water beyond the permissible limit of 1.5 mg/L is a major health problem in India. Nearly 90% of rural population of the country uses ground water for drinking and domestic purposes and due to excess Fluoride in ground water (Table-1), a huge rural population is threatened with health hazards of Fluorosis.

Table 1. Occurrence of Fluoride in Ground Water of India

Sl. No.	State	No. of District Affected	Districts
1.	Andhra Pradesh	16	All districts except Adilabad, Nizamabad, West Godavari, East Godavari, Vishakhapatnam, Srikakulam, Vizianagaram
2.	Assam	2	Karbi Anglong,Nagaon
3.	Bihar	5	Daltonganj,Gaya,Rohtas,Gopalganj,Paschim Champaran
4.	Chhatisgarh	2	Durg, Dantewara
5.	Delhi	7	Central, South, West, East, South-west, North West, North East zones
6.	Gujarat	18	All districts except Dang
7.	Haryana	11	Rewari, Faridabad, Karnal, Sonipat, Jind, Gurgaon, Mohindergarh, Rohtak, Kurukshetra, Kaithal, Bhiwani
8.	Jammu & Kashmir	1	Doda

9.	Jharkhand	4	Giridih, Palamau,Pakur,Sahabganj
10.	Karnataka	14	Dharwad,Gadag,Bellary,Belgaum,Raichur, Bijapr,Gulbarga,Chikmaglur,Mandya, Bangalore (rural), Mysore, Manglore, Kolar, Shimoga
11.	Kerala	2	Palghat, Allepy
12.	Maharashtra	8	Chandrapur, Bhandara, Nagpur, Jalgaon, Buldhana, Amravati, Akola, Yavatmal
13.	Madhya Pradesh	13	Shivpuri,Jhabua,Mandla,Dindori,Chhindwara,Dhar, Vidisha, Sehore, Raisen, Mandsour, Neemuch, Ujjain, Seoni
14.	Orissa	18	Phulbani, Koraput, Dhenkenal, Angur, Boudh, Nayagarh, Puri,Balasore, Bhadrak, Bolangir, Ganjam, Jagatpur, Jajpur, Kalahandi,Keonjhar, Kurda, Mayurbhanj, Rayagada
15.	Punjab	9	Mansa,Faridkot,Bhatinda,Muktsar,Moga,Sangrur, Ferozpur, Ludhiana, Amritsar
16.	Rajasthan	32	All districts
17.	Tamil Nadu	8	Salem, Erode, Dharmapuri, Coimbatore, Tiruchirapalli, Vellore, Madurai, Virudunagar
18.	Uttar Pradesh	7	Unnao,Agra,Meerut,Mathura,Aligarh,Raibareli , Sonbhadra
19.	West Bengal	7	Birbhum,Bardhman, Bankura, Purulia, Malda, U.Dinajpur & D.Dinajpur

To combat the growing problem of fluorosis, it is of utmost importance to understand the distribution and occurrence of fluoride in ground water and work out strategies for its mitigation and management. Some of the options available for removal of fluoride from drinking water are –

i. Adsorption (Activated Alumina)
ii. Ion Exchange
iii. Nalgonda Technique
iv. Membrane (Reverse Osmosis)
v . Electro dialysis
vi. Alternate Fluoride free aquifer

Arsenic

Arsenic and its compounds are widely used in pigments, as insecticides and herbicides, as an alloy in metals and chemical warfare agents. Though synthetic organic compounds have now replaced arsenic in most of the uses, arsenic is still an element of interest in terms of environmental quality.

Arsenic is a metalloid. The common valancy of arsenic in unpolluted ground water of geogenic origin are +III & +V as hydrolysis species The dissociation constant of As(III) and As(V) acids are quite different

The fact that dominant dissolved species are either uncharged or negatively charged suggests that adsorption and ion exchange will cause little retardation as these species are transported along ground water flow path. Organic arsenic compounds such as methyl arsenic acid and dimethyl arsenic acid are not common in ground water.

The occurrence of Arsenic in ground water was first reported in 1980 in West Bengal in India. In West Bengal, 79 blocks in 8 districts have Arsenic beyond the permissible limit of 0.01 mg/L. About 16 million people are in risk zone. The most affected districts are on the eastern side of Bhagirathi river in the districts of Malda, Murshidabad, Nadia, North 24

Parganas and South 24 Parganas and western side of the districts of Howrah, Hugli and Bardhman. The occurrence of Arsenic in ground water is mainly in the intermediate aquifer in the depth range of 20-100m. The deeper aquifers are free from Arsenic contamination. Apart from West Bengal, Arsenic contamination in ground water has been found in the states of Bihar, Chhatisgarh and Uttar Pradesh &Assam. Arsenic in ground water has been reported in 12 districts In Bihar, 5 districts in U.P and one district each in Chhatisgarh & Assam states. The occurrence of Arsenic in the states of Bihar, West Bengal and Uttar Pradesh is in Alluvium formation but in the state of Chhatisgarh, it is in the volcanics exclusively confined to N-S trending Dongargarh-Kotri ancient rift zone. It has been reported in Dhemaji district of Assam. Table 2 shows the occurrence of Arsenic in ground water in some state of India.

Table 2 Occurrence of High Arsenic in Ground Water of Some States of India.

State	District	Name of affected blocks
Bihar	Bhojpur	Barhara, Shahpur, Koilwar, Ara, Bihiya,Udawant nagar
	Patna	Maner, Danapur, Bakhtiarpur, Barh
	Begusarai	Matihani,Begusarai,Barauni,Balia,SabehpurKamal, Bachwara
	Khagaria	Khagaria,Mansi,Gogri,Parbatta
	Samastipur	Mohinuddin Nagar,Mohanpur,Patori,Vidyapati Nagar
	Bhagalpur	Jagdishpur,Sultanganj,Nathnagar
	Saran	Dighwara,Chapra Sadar, Revelganj
	Munger	Jamalpur,Dharhara,Bariarpur,Munger
	Katihar	Mansahi, Kursela, Sameli, Barari, Manihari, Amdabad
	Buxar	Brahmpur, Semary,Chakki,Buxar
	Vaishali	Raghopur, Hajipur, Bidupur, Desri, Sahdei Bujurg
	Darbhanga	Biraul
Chhatisgarh	Rajnandgaon	Choki (11 villages)
West Bengal	Malda	English Bazar,Manickchak,Kaliachak I ,II&III Ratuaand I and II
	Murshidabad	RaninagarI&II, Domkal,Nowda, Jalangi, Hariharpara, Suti I&II Bhagwangola I & II, Beldanga I&II, Berhampur, Raghunathganj I & II, Farakka, Lalgola and Satshahgani
	Nadia	Karimpur I&II,Tehatta I &II, Kaliganj, Nawadwip, Haringhata, Chakda, Santipur,Naksipara,Hanskhali, Krishnaganj, Chapra, Ranaghat I&II, Krishnanagar I & II.
	North 24 Parganas	Habra I & II,Barasat I & II, Rajarhat, Deganga, Beduria, Gaighata, Amdanga, Bagda ,Boangaon, Haroa, Hasnabad, Basirhat I & II,Swarupnagar,Barackpur I & II, Sandeshkhali II
	South 24 Parganas	Baraipur,Sonarpur,Bhangar I & II,Joynagar I,Bishnupur I & II,Mograhat II,Budge Budge II
	Bardhman	Purbasthali I & II,Katwa I & II and Kala II
	Haora	Uluberia II and Shampur II
	Hugli	Balagarh
Uttar Pradesh	Ballia	Belhari,Baria,Muralichhapra,Reoti,Bansdih,Dubhar and Maniar
	Lakhimpur Kheri	Palia,Nighasan,Ramia,Dauralwa and Issanagar
	Balrampur	Tulsipur,Gainsari,Pachparwa and Utaranla
	Gonda	Katrabazar,Haldarman,Tarabganj and Nawalganj
	Siddharth Nagar	Itawa and Khumiaon

The remedial options available for getting Arsenic free water are

1. Development of ground water from Arsenic free aquifers
2. Piped water supply from surface water sources.
3. Dilution of ground water with surface water
4. Treatment of ground water for removal of arsenic using adsorption (Activated alumina /Granulated ferric hydrated oxide) or precipitation and coagulation technique.
5. Rain water harvesting

Iron

Iron in an essential element for both plant and animal metabolism. Both ferrous and ferric iron are wide spread minor component of most sediments. Soil development processes result in increase in iron content. The concentration of iron in natural water is controlled by both physico chemical and microbiological factors. In aqueous solution iron is subject to hydrolysis and iron hydroxides are formed during these reactions, especially the ferric form having very low solubility.
The reaction of iron in aqueous solution is affected by redox potential and pH of the solution. In natural water, pH mostly ranges from 5 to 9 and as such is not low enough to prevent hydrolysis under oxidising conditions. Practically all the iron is precipitated as hydroxides. This ferric hydroxide may exist in colloidal suspensions in the range of 5 to 8. Organic rich water particularly those with humic acid, can contain dissolved iron over a large range of redox conditions. Organic compounds present in water consume dissolved oxygen which lowers the pH of water because of production of CO_2 reducing both pH and Eh. An additional factor involved in the mobility in iron in ground water is the presence of bacteria. These bacteria are Gallionela, Leptothrix and Thiobacilhus. Decay of these bacteria produces unpleasant odour in the water.

High concentration of Iron in ground water has been observed in more than 1.1 lakh habitations in the country. The highest value(49 mg/L) has been found in a hand pump at Bhubaneswar. Ground water contaminated by iron has been reported from Assam, West Bengal, Orissa, Chhattisgarh, and Karnataka. Localized pockets are observed in states of Bihar, UP, Punjab, Rajasthan, Maharashtra, Madhya Pradesh, Jharkhand, Tamil Nadu, Kerala and North Eastern States.

The remedial methods available for removing Iron from drinking water are-

i) Chemical Oxidation
ii) Aeration
iii) Ion exchange method

Nitrates

Aqueous geochemical behaviour of nitrogen is strongly influenced by vital importance of the element in plant and animal nutrition. The most common contaminant identified in ground water is dissolved nitrogen in the form of nitrate (NO_3).

Nitrate in ground water generally originates from nitrogen sources on the land surface in the soil zone or shallow subsoil zones where nitrogen rich wastes are buried. In some situations nitrate that enters the ground water system originates as nitrate in wastes or fertilizers applied on the land surface. These are direct nitrate sources. In other cases nitrate originates by conversion of organic nitrogen. Ammonification and nitrification are processes that normally occur above the water table generally in the soil zone, where organic matter and oxygen are abundant.

Though various nitrogen products are available in the nitrogen cycle, the content of nitrate in Ground Water is probably controlled by nitrification which is directly related to the capacity of soil microorganisms to convert ammonia to nitrate to provide growing plants with the assimilable form of nitrogen.

Concentrations of nitrate in the range commonly reported for ground water are not limited by solubility constraints. It moves with ground water with no transformation and / or no retardation. Very shallow ground water in highly permeable sediment or fractured rocks commonly contains considerable dissolved oxygen and in these hydrological environment nitrate commonly migrates large distances from input areas.

Nitrate is a very common constituent in the ground water, especially in shallow aquifers. The source is mainly from man made activities. In India, high concentration of nitrate(more than 45 mg/l) has been found in many districts of Andhra Pradesh, Bihar, Delhi, Haryana, Himachal Pradesh, Karnataka,Kerala, Madhya Pradesh,Maharashtra , Orissa. Punjab, Tamil Nadu, Rajasthan, West Bengal and Uttar Pradesh. The highest value being 3080 mg/L found in Bikaner, Rajasthan

The remedial methods available for removing Nitrate from drinking water are-

1. Reverse Osmosis
2. Ion Exchange
3. Bio remediation
4. Blending