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Assessment of Groundwater Quality based on Physico-chemical Characteristics for Irrigation and Drinking Purposes in the Coastal area of West Bengal, India

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Abstract—*The study area in the coastal zone of West Bengal falls under a monsoon type of climate. Based on various physico-chemical water quality parameters and major ion chemistry the suitability of groundwater quality for agricultural and drinking purposes was assessed in the coastal area of West Bengal (India). The present study is based on randomly collected forty-six representative groundwater samples from bore wells/ tube wells in the study area. The water chemistry of samples were analysed using standard procedures for various ions, comprising of* Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, CO_3^{-2}, HCO_3^{-}, SO_4^{-2}, NO^{3-}, Cl^{-} *and* F^{-}. *The groundwater pollution with respect to chloride, fluoride and nitrate can be mainly attributed to the large-scale discharge of municipal wastes directly into the open drainage system of the area and extensive use of fertilizers for agricultural activities in the study area. It has been observed that groundwater samples classification based on chloride, 54.34% of water sample falls under 'safe', to 'tolerable' and 21.74% of water samples fall under 'health hazard' category. Further, classification of groundwater based on conductivity, shows that most of the groundwater samples fall in 'tolerable' to 'safe' category. As per the Wilcox irrigation water classification 46% of the groundwater samples fall under good to permissible category and 37% samples falls under the permissible to doubtful category. It is concluded that as per the U.S. Salinity Laboratory Classification, most of the groundwater samples of the study area fall into the category of the 'good to moderate' class (C3-S1) (58.69%) (high salinity-low SAR) and 36.95 % under C3-S2 (high salinity-medium SAR) category. Based on the analytical results of water quality it is also concluded that the concentrations of these ions are above the permissible limits for irrigation and drinking purposes.*

1. INTRODUCTION

It is well known that groundwater is very crucial for our survival and it plays an important role in human life and development. An understanding of physico-chemical characteristics of groundwater is essential in determining its usefulness for agricultural, domestic and industrial purposes. A good quality of groundwater has the potential to increase crop productivity under good soil quality and better water management practices. The suitability of groundwater for irrigation purposes depends on various factors such as the soil type, salt tolerance characteristics of crop plants, drainage characteristics of soil, climatic conditions and quality of water (Michael, 1990; Mukherjee, et.al, 2005). The under groundwater always contains some amount of soluble mineral salts dissolved in it. The variety and quality of these mineral salts depend upon the aquifer sources for recharge of the groundwater and the composition of rock-soil strata through which it flows. The excess quantity of soluble salts beyond tolerance limit of plants may be very harmful for a variety of crops. Hence, a better understanding of the physico-chemical characteristics of groundwater is essential to properly evaluate the suitability of groundwater quality for irrigation and drinking purposes. Quality analysis and presentation of geo-chemical data of the representative groundwater samples in the form of graphical charts such as Wilcox salinity diagram and U.S. salinity diagram help us in recognizing various hydro-geochemical types in a groundwater basin. An analysis of the various chemical constituents of groundwater also gives insight on the geochemical evolution of groundwater bodies in the region as well as identification of sources of recharge in the areas. The present study has been undertaken with the objective of (a) chemical characterization of groundwater samples of the study area and (b) to evaluate their quality to assess their suitability in the coastal area for irrigation and drinking purposes.

2. ABOUT THE STUDY AREA

The northern portion of the study area has geo-morphological features of a mature delta and was formed prior to the southern portion (being is a part of Bengal delta). The delta formation process in the coastal area of West Bengal is still going on in the southern part of the coastal area, which is mostly covered by the Sundarban forest. The geo-morphological features in the area includes levees along the Hooghly, Malta and Bidyadhari rivers and marshes bordering along levees and islands. The drainage system in the coastal area comprises of the Hooghly, Malta, Bidyadhari & Thakuran rivers, their many tributaries and distributaries. They form a network of rivers and tidal creeks, especially in the Sundarbans region. The thick sequences of quaternary sediments cover the entire coastal district of West Bengal. The soil quality in the region varies from deep fine loamy to deep fine clayey soils. In the southern parts of the study area, the soil is mostly saline in nature. The study area being closer to Sunderban delta is rich in mangrove forest resources and total forest cover in the district is about 1,706 sq. km. The Sundarbans mangrove forest nurtures and flourishes a wide diversity of flora and fauna. It is the only mangrove forest providing habitat for Royal Bengal tiger in the world.

The population is predominantly rural and agriculture is the main occupation of the people in the region. Net area available for crop cultivation is nearly 3,928 sq. km. Rice is the main crop followed by vegetables and pulses. Orchards and gardens are localized in and around Baruipur area. Only about 15% of the total geographical area is covered under irrigation. Regional disparity in developmental activities is very prominent in this district. While the northern and north-eastern parts (area adjacent to Kolkata), have experienced significant development, the Sundarbans region shows very poor level of development in all aspects. Main industries in the coastal region are cotton and jute textile, plastic, engineering, metallurgical and polyethylene, leather, drugs and pharmaceutical products. The important industrial centers in the region are Baruipur, Bata, Budge Budge, Birlapur, Falta and Sonarpur.

The climate of the region is characterized by very hot summer, cool winter, high humidity and heavy rainfall during the monsoon season. The average rainfall in the area is around 1,722 mm. The mean annual temperature in the study area ranges from $25^{O}C$ to $27.5^{O}C$. The mean summer maximum temperature is around $40^{O}C$ and mean winter temperature is nearly $10^{O}C$.

3. .MATERIALS AND METHODS

The representative groundwater samples were collected from forty-six locations from the tube wells/ bore wells and analyzed for various physico-chemical parameters as described by the American Public Health Association (APHA, 1995). These groundwater parameters includes pH, electrical conductivity, total dissolved solids, important cations such as sodium, calcium, magnesium and potassium as well as anions such as chlorides, fluorides, carbonates, bicarbonates, , nitrates and sulphates. Groundwater quality for drinking purposes was analyzed by considering the WHO (1971) and ISI (1983) standards. The pH and electrical conductivity (EC) of groundwater samples were measured in the field at the time of collection of these samples by using pH meter and digital conductivity meters, respectively. Total hardness (TH) as $CaCO_3$, calcium (Ca^{2+}), magnesium (Mg^{2+}), carbonate(CO_3^{2-}), bicarbonate (HCO^{3-}) and chloride (Cl^-) were analyzed by volumetric methods. Sodium and potassium were determined by flame photometer. Nitrate (NO^{3-}) and fluoride (F^-) were determined by using ion analyzer. Sulphates (SO_4^{2-}) were estimated by using the calorimetric technique. The quality parameters like salinity (EC), permeability index (Doneen's Permeability Index, Doneen, 1964), toxicity due to chloride and sodium (SAR), and parameters causing miscellaneous problems to soil-water-plant relationships (bicarbonate, RSC, sulphate) were determined to assess the irrigation suitability of the groundwater. The data was also plotted on Wilcox diagram and U.S. Salinity Laboratory Diagram (USSL Staff, 1954).

4. RESULT INTERPRETATION AND DISCUSSION

Suitability of Groundwater for Irrigation Purpose

The values for the percent sodium in the study area varies from 11.71- 93.83%. A sodium percentage of more than 60% is considered unsafe for irrigation purposes. The irrigation water containing a high proportion of sodium will increase the exchange of sodium content of the soil, affecting the soil permeability, and the texture makes it hard to plough and unsuitable to seeding emergence (Triwedy and Goel, 1984). If the percentage of Na^+ with respect to (Ca^{2++} Mg^{2+} Na^+) is above 50% in irrigation water, calcium and magnesium exchange with sodium, thus causing deflocculation and impairment of the tilth and permeability of soils (Karanth, 1987). Based on conductivity classification 52.17 % of groundwater samples falls in ‘tolerable’ (1000-1500 micro mhos/cm) and 28.26 % under ‘safe’ (<1000 micro mhos/cm) category. Groundwater classification based on chloride, 21.74 % of water sample fall under ‘health hazard’ category, 36.95 % of water sample falls under ‘safe’ and 17.39 % of samples are under ‘tolerable’.

A more detailed analysis of groundwater, however, with respect to the irrigation suitability of the groundwater, was made by plotting the data according to the diagram (SAR and salinity hazard) of the US Salinity Laboratory of the Department of Agriculture (US Salinity Laboratory Staff, 1954) and Wilcox classification. According to the Wilcox irrigation water classification scheme majority of the water samples (46 %) falls under ‘good to permissible’ category whereas 37% falls under the ‘permissible to doubtful’ category. According to the residual sodium carbonate (RSC) concentration, groundwater sample falling under different categories of unsuitable, marginal and safe were analyzed. According to this classification, low-salinity water (<200 mg/l) may be used for all types of soils. Most of the groundwater samples of the study area falls into the category of the ‘good to moderate’ class (C3-S1) (58.69%) and 36.95 % under C3-S2 category.

Suitability of Groundwater for Drinking Purpose

The pH values of groundwater samples in the study area ranges from 7.3 to 8.1, clearly indicating an alkaline type of groundwater. Total dissolved solids (TDS) in the study area varies in the range of 593.8-2802 mg/l. TDS values obtained in the study area are beyond the desirable limits but only two samples have TDS values more than the permissible limits (ISI, 1983), making the water unsuitable for various domestic activities. The groundwater in the study area falls under fresh (TDS<1000 mg/l) to brackish (TDS>1000 mg/l) types of water (Freeze and Cherry 1979). The electrical conductivity (EC) values range from 753 to 4120 micro mho/cm at 25^0 C. The larger variation in EC is mainly attributed to anthropogenic activities and to some extent geochemical processes prevailing in this region. In the study area, the Na^+ concentration in groundwater ranges from 22-685 mg/l. The concentration of Ca^{2+} in the study area ranges from 10-146 mg/l. The concentration of Mg^{2+} found in the groundwater samples of the study area vary in the range of 6-98 mg/l. The major source of magnesium (Mg^{2+}) in the groundwater is due to ion exchange of minerals in rocks and soils by water. The concentration of K^+ in the study area varies from 1 mg/l to 50 mg/l. Bicarbonate (HCO^{3-}) is the dominant anion, followed by chloride (Cl^-) and sulphate (SO_4^{2-}). The level of bicarbonate in the study area ranges from 360-1080 mg/l, the source of most of the bicarbonates in the water being sewage and various human activities. Water with a high concentration of bicarbonates, if used for irrigation, may cause white deposits on fruits and leaves, which is undesirable (Subrahmanyam and Yadaiah 2001). The concentration of chloride ranges from 28-823 mg/l, the large variation is attributed to geochemical processes, and to contamination by sewage wastes. Three groundwater samples out of the total showed extraordinary high values of chloride. The fluoride (F^-) content in the groundwater shows a range of 0.05-1.6 mg/l. The occurrence of low fluoride concentration in the groundwater may be either due to absence of fluoride containing minerals in the strata through which the groundwater is circulating. It could be also due to too rapid freshwater exchange, with the result that the normal process of concentration through evaporation or evapo-transpiration is not very effective in raising the fluoride content of the groundwater to high values prevalent in some parts of the study area. Nitrate (NO^{3-}) concentration in the study area varies in the range of 0.3-55 mg/l. Nitrate (NO^{3-}) concentration of all the samples falls below the desirable limits, except one sample. The main source of Nitrate (NO^{3-}) in the groundwater is attributed to increased usage of fertilizers in the agricultural field, decaying organic matters and sewage wastes (Karanth, 1989). The range of sulphate in the water ranges from 1.1-110 mg/l.

5. CONCLUSION AND RECOMMENDATIONS

Groundwater quality in the coastal area of West Bengal is analyzed to classify the groundwater into different categories for the drinking and irrigation purposes. The overall groundwater quality of the study area is suitable for drinking purposes as well as for irrigation purposes. In the present study an attempt was made to analyze the groundwater quality and classify these samples into different categories for the irrigation and drinking purposes. The pH values of groundwater in the study area range from 7.3 to 8.1, indicating an alkaline type of groundwater. TDS values of most of the groundwater samples in the study area are beyond the desirable limits. According to the Wilcox irrigation water classification, majority of the water samples falls under good to permissible category (46%) and 37 % under the permissible to doubtful category. Sodium concentration in groundwater ranges from 22-685 mg/l and Calcium range from 10-146 mg/l. Potassium in the study are varies from 1 mg/l to 50 mg/l. Bicarbonate is the dominant anion, followed by chloride and sulphate. Nitrate concentration of all the samples falls below the desirable limits, except one sample. The fluoride content in the groundwater shows a range of 0.05-1.6 mg/l. Classification based on conductivity, shows 52.17 % groundwater samples falls in 'tolerable' and 28.26 % under 'safe' category. Groundwater classification based on chloride, 36.95 % of water sample are under 'safe', 17.39 % under 'tolerable' and 21.74% of water samples fall under 'health hazard' category. Most of the groundwater samples of the study area comes into the category of the 'good to moderate' class. The ground water quality does not show any clear-cut regional trend in any direction (South-North or East-West). Therefore, it is recommended to carry out the analytical work on groundwater quality variation in greater detail and covering additional areas. A GPS-based groundwater sampling strategy will be useful for accurate correlation of chemical signatures with subsurface hydrogeology. More number of groundwater samples should be collected from different geographical locations to establish physic-chemical variations and trends in the study area.

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REFERENCES

1. APHA, (1995). Standard Methods of analysis of Water and Waste Water (19th Edn.), American Public Health Association, Washington D.C.
2. Doneen, L. D. (1964). Notes on Water Quality in Agriculture, Water Science and Engineering Paper 4001, Dept. of Water, Science and Engineering, Univ. of California,Davis, USA.
3. Freeze, R.A. and Cherry, J.A. (1979). *Groundwater*, Prentice Hall, Englewood Cliffs.
4. ISI (1983). Drinking water standards, Table 1. Substance and characteristics affecting the acceptability of water for domestic use 18, 10500. Indian Standard Institute, New Delhi.

5. Karanth, K. R. (1987). Groundwater assessment, development and management, Tata McGraw Hill, New Delhi.
6. Karanth, K. R. (1989). Hydrogeology, Tata McGraw Hill, New Delhi.
7. Michael, A. M. (1990). *Irrigation: Theory and Practices*, Vikash Publishing House Pvt. Ltd., New Delhi, pp. 801.
8. Mukherjee, S.; Kumar, B.A. and Kortvelyessy (2005). Assessment of Groundwater Quality in the South 24-Parganas, West Bengal Coast, India. *Journal of Environmental Hydrology*, Vol 13, pp. 1-8.
9. Mukherjee, S. and Kumar, B.A. (2009). Groundwater Quality Variation in South 24-Parganas District, West Bengal Coast, India. Bhu-Jal News Quarterly Journal, Vol.24, No.1 pp. 73-78.
10. Richards, L. A. (1954). Diagnosis and improvement of saline and alkali soils. *Agriculture Handbook 60*. ARS-US Department of Agriculture. Riverside, CA.
11. Singh, O.; Rai, S. P. and Kumar,V. (2002). Ground Water Quality Assessment for Irrigation in Jammu & Kathua District, J & K, *Journ. Applied Hydrology*, Vol. XV, No.2 & 3, pp. 9-19.
12. Subrahmanyam, K. and Yadaiah, P. (2001). Assessment of the industrial effluents on water quality in Patancheru and environs, Medak district, Andhra Pradesh, India. *Hydrogeol. J.*, 9:297-312.
13. Triwedy, R. K. and Goel, P. K. (1984). Chemical and biological methods for water pollution studies, Environ Pub. Karad, India.
14. Turner, R. K. and Bateman, I. J. (Ed.) (2001). *Water Resources and Coastal Management*: *Managing the Environment for Sustainable Development*, An Elgar Reference Collection, Cheltenham, U. K.
15. USSL Staff, (1954). Diagnosis and Improvement of Saline and Alkali Soils, USDA Handbook No.60, U.S., GPO, Washington, D.C., USA.
16. Wilcox, L. V. (1955). Classification and use of irrigation waters. US Dept. Agriculture Circular.
17. Wu. Y. (2003). Mechanism analysis of hazards caused by the interaction between groundwater and geo-environment, *Environmental Geology*, Vol. 44, pp. 811-819.