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"A Review on Evaluation of Ground Water Quality Parameters for its Use in Varied Sectors"

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Abstract:

Water is the most significant need without which human life is impossible. Its use in varied sectors such as drinking, domestic, agricultural (irrigation), industrial, etc. makes it the most "to be dependent" resource in the present day scenario. It is available to human beings in several forms such as surface water, sub-surface water, groundwater, rainwater, of which, the most reliable is the groundwater since it is stored underneath the ground, thereby forming the water table in that particular area. However, due to the emission of point and non-point water pollution from excessive industrial and agricultural activities, respectively, followed by their percolation into the ground, the quality of groundwater has become a matter of serious concern in places, mainly within the periphery of such activities. Hence, prior to application of groundwater for any purpose, its suitability, in terms of physical, chemical or biological has to be determined with great importance. The evaluated values of ground water quality parameters such as Sodium Absorption Ratio, Electrical Conductivity, Residual Sodium Carbonate, Sodium Percentage, pH, Turbidity, Salinity, Total Dissolved Solids, Total Hardness, Magnesium Hazard, Nitrates, Phosphates, etc. that have a true and larger impact in any application needs be evaluated to the most accurate extent. This paper presents a review on such various physic-chemical water quality parameters determined by different researchers spatially around the globe.

Keywords: Water Quality Parameters, Groundwater, Irrigation, Point Water Pollution, Non-Point Water Pollution

Introduction:

Groundwater is one of the vital source of utilizable water. It is formed when rainwater infiltrates into the soil and percolates deeply to form the water table. In most places around the globe, people mostly rely upon the groundwater for its utilization amongst various sectors - be it for drinking, domestic, agriculture, industrial, etc. Though in the recent days, rainwater harvesting technique is being introduced and implemented, it has not been able to make its place in most areas, especially the rural ones; the reason being lack of proper knowledge, financial in-capabilities and lack of required space for setting up the structure in high population density areas.

Various methods of extracting the groundwater are in the form of open or dug wells, tube-wells, bore-wells and large area excavation (ponds). Open or dug wells are used in large percentage for withdrawal of groundwater in rural areas, whereas in urban areas tube-wells and bore-wells are mostly used.

In the present day scenario, the fact that the groundwater is exposed to different forms of pollutants cannot be neglected. The release of unwanted materials from industries is the prime cause of point water pollution. At the same time, agricultural activities which involves the use of chemical fertilizers, releases pollutants causing non-point water pollution which gets percolated and mixed with the groundwater. Due to the increased population day by day, the pressure for meeting up the minimum nutrient requirements have led to the increase in these agricultural and industrial activities, resulting in emission of more point and non-point water pollution. Groundwater quality has become a matter of serious concern as it creates heath risk and other damages if not evaluated properly prior to its use in any sector, especially for the purpose of drinking, and other domestic activities. Groundwater is also a huge source for irrigation and hence needs to be assessed with great importance before subjecting it to agricultural field application, as it may create serious crop health as well as soil health issues.

Groundwater gets polluted when contaminants such as pesticides, fertilizers and waste leaches from landfills and septic systems, make their way into an aquifer, rendering it unsafe for human use. Once polluted, an aquifer may remain unusable for decades. Groundwater can also spread contamination far from the original polluting source as it seeps into streams, lakes, and oceans.

Various indicators of water quality such as pH, Electrical Conductivity (EC), Total Hardness (TH), Turbidity, Sodium Absorption Ratio (SAR), Sodium Hazard (SH), Residual Sodium Carbonate (RSC), Residual Sodium Bicarbonate (RSB), Potential Salinity (PS), Magnesium Absorption Ratio (MAR) or Magnesium Hazard (MH), Kelley ratio (KR), Permeability Index (PI), concentrations of Calcium (Ca2+), Magnesium (Mg2+), Sodium (Na+), Potassium (K+), Bicarbonate (HCO_3^-), Chloride (Cl^-), Nitrate (NO_3^-), Sulfate (SO_4 2 $^-$), and Fluoride (F^-), etc. are being considered as water quality parameters by different researchers, depending upon the need of their area of research.

Review of Literature:

The extensive review of literature was performed by referring to various standard journals and books published by different authors regarding their works related to water quality parameters.

Haloi and Sarma (2011) conducted a study to focus on ground water quality assessment of parts of Brahmaputra flood plain located in BarpetaDistrict of Assam. A total of 20 different water samples were analyzed to check the contamination offluoride, nitrate, sulphate and iron by employing standard analytical techniques of APHA. Fluoride concentration was measured by the SPADNS method at 570 nm and nitrate content was measured at 410nm by the use of UV–VIS spectrometer. Sulfate analysis was done by turbidimetric method and iron content was measured by using Phenanthroline Method (APHA-AWWA-WPCF, 1995) at 510 nm. Statistical analysis i.emean, variance, standard deviation, median, range of variation, skew-ness, kurtosis were computed for the water quality parameters. It was found that due to poor maintenance and lack of water treatment, the iron content of groundwater was high and hence not suitable forfood processing, dyeing, bleaching, etc.Most water samples were alkaline in nature with narrow pH. However, the concentrations of sulfate and nitrate in groundwater were found to be safe for drinking purpose as the values were within the approved of WHO guideline.

A research work was conducted by Venkatesan et al. (2013) where water quality assessment was performed in Timchirappalli of Tamil Nadu. Due to the presence of distillery industry effluents in the area, they doubted that the water resources in that location might be exposed to some kind of pollution. They made the use of clean plastic bottles to collect 6 samples in 3 trials with a frequency of two weeks (within a month), from different locations in the periphery of distillery unit. Concentrations of pH and dissolved oxygen (DO) were calculated just within half an hour after sample collection. Water quality parameters which help to indicate the suitability and safety of water for domestic and drinking purposes such as pH, sulfates, chlorides, alkalinity, total dissolved solids (TDS), nickel, chromium, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), copper, zinc, lead, cadmium, nickel and manganese were analyzed and then calculated values were compared with the standard limits set by World Health Organization. It was observed from the results that, hardness concentration calculated by Ethylene Diamine Tetra Acidic (EDTA) method after three systems of trial was 3.68 times the standard value prescribed by WHO for drinking purposes. Average pH concentration of all 6 locations was found to be 6.84 which is within the standard limits set by WHO. Average Chloride ion concentration which was measured by Argentometric Titrations method conducted in laboratory was found as 570 ppm, which is twice the WHO standard limit. Sulfate ion concentration was determined by turbidimeter and the average value was found to be 280 ppm, which is twice the least desirable value prescribed in WHO guidelines. TDS values for sixth location exceeded the desirable value prescribed by WHO, by 5.66 times. Other parameters such as Chromium, Nickel, DO, BOD and COD were found to be within the standard range. The study concluded that surface water quality was not vulnerable; however it was advised not to use the water for drinking and domestic purposes without proper treatment.

Aghazadeh et al. (2016) conducted a study to investigate the hydro-chemical parameters of groundwater and its suitability for the purposes of drinking, irrigation and industrial purposes. They collected 77 samples for analyzation of various ions concentration in the samples. The study revealed that nature of groundwater in the area is hard to very hard and mildly alkaline to brackish. From the hydrochemistry diagrams, it was found out that groundwater types were Ca, Mg-HCO_3, Na-HCO_3 and NaCl. The mineral saturation index was calculated which indicated that groundwater samples were saturated with carbonate minerals and under saturated with sulfate minerals like gypsum and anhydride. Factors which influence the water quality of the area are mineral weathering, ion exchange, anthropogenic activities, etc. However, the research work also indicated that groundwater was not exposed to heavy metals. In this study, they made use of various water quality indices, which were calculated and then compared with the standard values prescribed as safe by WHO. The quality of groundwater was found suitable for use in drinking, industrial and agricultural purposes.

Saleem et al. (2016) conducted a study in the greater Noida region of Uttar Pradesh to assess the ground water quality of the area by using water quality index. They considered nine physico-chemical water quality parameters such as Calcium, Magnesium, Chloride, Sulphate, Total Hardness, Fluoride, Nitrate, Total Dissolved Solids, Alkalinity to be evaluated from the 10 samples collected each from 10 different locations since 2015, through different sources such as Government hand pumps (GHP), General hand pumps (HP), Borewells (BOR) and as per the methods prescribed in American Public Health Association manual [APHA-2320, 1999]. Water quality index for the samples were calculated and according results were compared with the standard values as prescribed by organizations such as Bureau of Indian Standards (BIS), Bureau of Indian Standards (BIS, 2012) and World Health Organization (WHO, 2012). Results revealed that water samples were of good quality, whereas only 10% water samples came under moderately poor category. The value of water quality index ranged between 16.49 and 64.65. Hence, the study implied the need of water treatment measures in order to protect the groundwater from further contamination.

Alexander et al. (2017)in his study, stated that the importance of utilization of groundwater in order to meet up the ever increasing demand of increasing population.However the water quality in aquifers is the only constraint. Groundwater quality assessment in the aquifer has become essential to ensure its safety for different purposes. However, due to lack of an effective monitoring system and considering the spatial variability of water quality, different chemical, physical, and biological water quality parameters needs to be evaluated.

The study conducted by Abbasnia et al. (2018) evaluated the groundwater quality and its suitability for irrigation purpose, by using GIS in villages of Chabahr city, Sistan and Baluchistan province in Iran. They collected water samples from 40 open dug wells to analyze the chemical parameters sucg as EC, SAR, Na^+, Cl^-, pH, TDS, $HCO_3^-$and accordingly Irrigation Water Quality Index (IWQI) was determined. Among the 40 collected and IWQI analyzed samples, 40% of the samples were classified as excellent water and the rest 60% of the samples in good water category.

Chaudhary and Satheeshkumar (2018) conducted a study in three different canal catchment areas of arid north-west Rajasthan to illustrate the qualitative analysis of groundwater and its suitability for better analyzation of groundwater geo-chemistry of those areas. Most of the bulk samples resulted in higher values of EC, TDS, TH and fluoride, and hence the water was not found suitable for drinking purposes without subjecting it to proper quality purification. Major ions in the collected samples was found in following the order of $Na^{+} > Ca^{+2} > Mg^{+2} > K^{+} = Cl^{-} > HCO^{3-} > SO_4^{-2} > NO^{3-} > F^{-}$. As the source of irrigation for the area is limited to groundwater only, the irrigation quality parameters such as sodium absorption ratio (SAR), sodium percentage (Na%), residual sodium carbonate (RSC), residual sodium bicarbonate (RSB), Kelley's index (KI), potential salinity (PS), magnesium hazard (MH), Mg/Ca ratio and permeability index (PI) were also determined and studied with great importance together with with USSL, Wilcox and Doneen diagrams. Cl^{-} and Na^{+} were found to be predominant in most of the collected samples. Moreover, while working with the Gibbs variation diagram, it was revealed that groundwater chemistry was mainly impacted by evaporation–crystallization. This study implied that groundwater of the area should be put under some treatment process for its use in irrigation purposes. It was also deduced from the study that geology of the area itself is the main reason for poor groundwater quality in this area. Due to exceeded levels of major parameters such as TDS and F^{-} from that of standard safe limits set by different organizations, water could not be utilized for drinking purpose and irrigation purposes. The authors suggested limited use of nitrogen fertilizers to reduce risk of nitrate infiltration in groundwater and mixing of groundwater with some amount of canal water for making the water safely usable for drinking and irrigation.

In the research conducted by Rao and Latha, 2019, they mentioned that Sodium Absorption Ratio (SAR) is one of the most vital irrigation suitability indicators that measure sodium or alkali hazards. Percent of sodium or sodium hazard is one of the most vital indices to determine water quality index. The surplus amount of sodium with carbonate ion will help to convert the soil into alkaline soil. In contrast, sodium mixed with chloride ion will accelerate the formation of saline soil, which ultimately deteriorates the infiltration capacity of the soil and reduces plant growth (Various organizations like the Bureau of Indian Standards (BIS), World Health Organization (WHO), Indian Council of Medical Research (ICMR), Food and Agriculture Organization (FAO), etc. mentioned the standard limit of each chemical parameters, beyond which health hazards as well as low productivity in agriculture, are expected (Rao and Latha, 2019).

Rumuri & Manivannan (2020) conducted a study to identify the major factors controlling groundwater chemistry in agricultural area of Kattumannarkoiltaluk, India. The study revealed the existence of three major hydro-chemical facies, viz. Ca-HCO_3 water type, Mixed Ca-Mg-Cl water type and Ca-Cl water type. Ca-HCO_3 and Ca-Cl water types suggest mineral dissolution, an interaction between rock- water and recharge of freshwater. Mixed Ca-Mg-Cl water type indicates, mixing of high salinity water caused from surface contamination sources, such as irrigation return flow with existing water followed ion exchange process.

Sutradhar and Mondal (2021) calculated the concentration and magnitude of twelve parameters like pH, Electrical Conductivity (EC), Total Hardness (TH), Calcium (Ca2+), Magnesium (Mg2+), Sodium (Na+), Potassium (K+), Bicarbonate (HCO_3^-), Chloride (Cl^-), Nitrate (NO_3^-), Sulfate (SO_4 2 $^-$), and Fluoride (F^-) in their research work to control ground water quality through a proper water treatment process and subsequentlyutilizing the waterfor irrigation and drinking purposes, in SuriSadar Sub-division, West Bengal. A total of 47 samples were collected by the Central Ground Water Board (CGWB). Hydro-chemical character of the water samples were analyzed by the use of Piper diagram, Schoeller diagram, and Chadha diagram. They employed a composite rating index known as Water Quality Index, which revealed that in the eastern part of SuriSadar Sub-division, 65.22% samples were of very good quality water, 17.39% samples required mild restriction prior to use, 4.35%samples needed moderate restriction, and 13.04% samples were of very poor quality which required severe restrictions prior to its use for irrigation.

Conclusion:

From the above reviews of research works pursued by different people, it can be concluded that water quality varies significantly, spatially and temporally, and so do the parameters. The importance of water quality parameters relies on the fact that, it leads to better understanding of relationship between water quality and use of groundwater for different purposes. The selection of ground water quality parameters to be employed for a certain research depends upon various factors such as area of research work, purpose of research, soil type and anthropogenic activities surrounding the study area. Parameters in need of consideration for a study may also vary temporally. While conducting a water quality assessment at any place, the minimum and maximum number of water samples to be collected, depends upon the accuracy of results required, based on the purpose of research.

Water quality index (WQI), is a significant composite rating index which is employed to determine the suitability of water for any purpose. WQI enables anyone to analyze quality of water by converting complex hydro-chemical data into some simpler form.

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