Analysis of Total Dissolved Solids and Electrical Conductivity in Different Water Supply Schemes of Taluka Chachro, District Tharparkar

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Abstract

The present work aims at investigating groundwater quality parameters, particularly total dissolved solids (TDS) and electrical conductivity (EC) of Taluka Chachro District Tharparkar in Sindh province of Pakistan. The sampling was performed at twenty six different locations for the assessment of water quality and the results were compared with World Health Organization (WHO) standards. Water samples were stored in sterilized plastic containers of 500 ml immediately after collection from the site. pH and water temperature of the samples were checked at the time of sampling, whereas, TDS and EC were examined in the laboratory. The pH measurement was made with calibrated Hanna 3910 pH meter, electrical conductivity with Hanna 2210 EC meter and total dissolved solids (TDS) with Hanna 103 TDS meter. The results revealed that the amount of both TDS and EC in all examined water samples was more than WHO standards. It was concluded from the study that the examined groundwater samples are unsafe for human as well as livestock consumption.

Keywords—Fuzzy logic controller, flexible alternating current transmission, PI controller, unified power flow controller.

1 Introduction

All living creatures living on the earth require water for their existence and evolution. Its acceptable quality as well as appropriate quantity is very important for their survival. Water has distinctive structure, as it has the capability to disperse, dissolve, and captivate a number of compounds that deteriorate the quality of drinking water. It dissolves contaminants from the surroundings through human and animals activities [1]. The water quality refers to the physical, chemical, biological parameters and other practices that may change the characteristics of water. Indeed, water quality could be affected in any step of the hydrological cycle. It might be influenced from the evaporation process in the atmosphere up to the end of its cycle when it is taken out from a well or spring. Groundwater contribution for drinking purpose in rural areas is about 88% where there is scattered population [2].

In Asia alone, around one billion people are directly dependent on the groundwater aquifers [3]. The drinkable water in Sindh province is mostly based on the surface water of the river Indus and groundwater from different aquifers. Tharparkar district covers an area of about 22,000 square kilometers with an estimated population of 1.2 million. Out of that, ninety five percent live in nearly two thousand scattered villages, especially adjoining any source of water. The arrangements required for the treatment and supply of surface water do not exist. Therefore, ground water is the only source of drinking water in rural communities which is being acquired from the dug wells at the average depth of 10 to 100 m. Furthermore, the quantity of groundwater is not enough to serve the people, thus they compel to use saline water. In fact, the groundwater of the area contains extremely high level of various salts and minerals and therefore it is not safe for the consumption of human as well as livestock population. It has been reported that the level of total soluble salts in the groundwater of Tharparkar is between 636 ppm to 9543 ppm. Although, different governmental and non-governmental organizations installed various tube wells, hand pumps through use of solar and wind energy systems, but these schemes have not been completely successful due to lack of technical expertise

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and maintenance issues. On average, the villagers take about four to six hours to get five pots (50 to 60 liters) of water from dug-wells using traditional tactics. Such practices not only take too much time but also require much labor and efforts.

It is reported that about 81 % population of the area relies only on rain-fed agriculture for their source of revenue as well as on farm animals. The total domestic water requirement of the Tharparkar district is about 0.25 % of the received rainfall. However, rain water harvesting capacity in the area is only 0.6 % of the total water requirement. Both rainwater harvesting and groundwater recharging are the most useful alternatives to tackle the water issue faced by the people. It has been observed that mega projects and overwhelming water schemes could not solve the water issues of the area and therefore it is recommended to support local practice sustained by renewable energy based community-managed water projects with proper maintenance to provide safe water to the people [1-3].

Among all water quality parameters, concentration of hydrogen ion (pH), temperature, total dissolved solids (TDS) and electrical conductivity (EC) are the focused parameters for every researcher. The pH of normal drinking water should be between 6.5 and 8.5 as given by World Health Organization (WHO). Acidic water can lead to corrosion of metal pipes and plumping system. On the other hand, alkaline water is generally considered to be safe; however, it could produce side effects in body at high alkanity [4]. Temperature influences the biological activity and growth of the organism in the water. It controls the types of organisms that can live in different water bodies. As temperatures vary from their desired range, the number of species decreases and finally they disappear at high temperature. Generally, the rate of chemical reactions increases as water temperature increases and vice versa. Groundwater have tendency to dissolves more minerals from the rocks at higher temperatures and thus acquires higher electrical conductivity. The situation could be opposite in view of the oxygen, dissolved in the water. When the water is warm, it holds less dissolved oxygen as compared to cold water. Thus, the survival of aquatic life is more problematic when there is less dissolved oxygen [4][5].

1.1 Measurement Techniques of Total Dissolved Solids (TDS)

TDS refer to any mineral salts and metals such as Ca, Mg, Fe, NaCl and sulfates dissolved in water that can pass through a 2.0 μm or smaller pore size filter. It is useful in describing chemical density of water. Direct measurements for TDS include gravimetric, and flow densitometry, which are considered as expensive and time consuming [6]. Total dissolved solids have widely been adopted as a quantifiable measurement of possible taste and odor complications or a controlled parameter in industrial effluents [7]. Although, TDS is not a fully specified parameter, yet its low cost and simplicity make it widely accepted variable in research [8]. Thus, in most research activities, electrical conductivity test is being substituted for TDS. Empirical relationships are mostly adopted to convert electrical conductivity into the concentration of total dissolved solids [9]. A suitable conversion factor could be developed when water samples are somewhat stable over time and are well embodied [10].

1.2 Relationship of Total Dissolved Salts and Electrical Conductivity

Water is a good solvent. The amount of total dissolved salts as well as electrical conductivity of water increase in the solution when the salts are dissolved in water. Thus, electrical conductivity test is used as correlated parameter of total dissolved salts. It gives an indication of the amount of total dissolved replacement or exchange. Actually, an electrical conductivity for groundwater is the ability of 1 cm^3 water to conduct an electric current at 25°C and is measured in micro Siemens per centimeter [10][11].

$$TDS(ppm) = 0.64 \times EC(\mu S\ cm) \tag{1}$$

Electrical conductivity depends on various factors such as depth of the collected samples, concentration of ions, groundwater movement, temperature and nature of soil. Temperature changes rely on the level of different salts in solution, thus it influence the electrical conductivity. In dilute solutions, an increase of 1°C temperature can increase the conductance of about 2% - 3%. It also increases with the increase of the amount of total dissolved salts in the solution [12]. Once the level of electrical conductivity is known, the amount of total dissolved solids can be estimated using a factor of 0.55 to 0.90 by converting electrical conductivity into the amount of total dissolved solids. Units used for measuring electrical conductivity of water are (μS/cm), (mS/cm) and (dS/m). EC value of water obtained from different locations is given in Table 1 [13]. The relationship of total dissolved solids and electrical conductivity for groundwater can be approximated with the help of Equation 2,

$$TDS = keEC \tag{2}$$

where TDS (mg/L or ppm) and EC (μS/cm) at 25°C. The correlation factor, ke is between 0.55 - 0.8. TDS

Water Collection Point	**EC (ÂţS/cm)**
Absolute Pure Water	0.055
Distilled Water	0.5
Power Plant Boiler Water	1.0
Deionized Water	0.1-10
Good City Water	0.5-1
Ocean Water	53
10 % NaOH	355
10 % H2SOÂŋ4	432

TABLE 1: Electrical Conductivity at various water collection units

reported in the freshwater range from 0 to 1000 mg/l, brackish water from 1000 to 10000 mg/l and saline water 10000 to 100000 mg/l [14]. Mishra et al. [15] reported that the permissible range of pH is 6.5 to 8.5, EC at 1000 (micro mhos/cm), and TDS at 500 mg/l. It is deduced from literature review that the level of total dissolved solids and electrical conductivity of drinking water quality must be within standards to make people healthy and fit. Otherwise, the consumption of higher TDS and EC water may cause complicated health issues to the people of the area. Thus, this study aims at investigating the concentration of total dissolved solids and electrical conductivity from Taluko Chachro of District Tharparkar. It may help to see whether there is short-term or long-term health risks for human population consuming groundwater prior to treatment or not.

2 Materials and Methods

Chachro is a Taluka (Tehsil) in the District of Tharparkar, Sindh, Pakistan as shown in Figure 1 and Figure 2. Twenty Six different locations of Taluka Chachro have been chosen for this study. Out of these, seven from private owned dug wells and nineteen groundwater samples were taken from government owned water supply schemes as shown in Table 2 and Table 3, respectively. Water samples taken for the analysis were stored in sterilized plastic containers of 500 ml immediately after collection from the site. Four water quality parameters, namely pH, temperature, TDS and EC were assessed following the standard protocols and by using standard instruments. pH and water temperature of the samples were noted at the time of sampling at the site, whereas, TDS and EC were examined in the laboratory. The pH of water samples was made with calibrated Hanna 3910 pH meter with glass electrode and reference internal electrode. Electrical conductivity was recorded with calibrated Hanna 2210 EC meter and total dissolved solids (TDS) with Hanna 103 TDS meter.

Water Collection Point	**EC (ÂţS/cm)**
Absolute Pure Water	0.055
Distilled Water	0.5
Power Plant Boiler Water	1.0
Deionized Water	0.1-10
Good City Water	0.5-1
Ocean Water	53
10 % NaOH	355
10 % H2SOÂŋ4	432

TABLE 2: Location of villagers owned water wells of Taluka Chachro

Water Collection Point	**EC (ÂţS/cm)**
Absolute Pure Water	0.055
Distilled Water	0.5
Power Plant Boiler Water	1.0
Deionized Water	0.1-10
Good City Water	0.5-1
Ocean Water	53
10 % NaOH	355
10 % H2SOÂŋ4	432

TABLE 3: Location of government owened water supply schemes of Taluka Chachro

3 Results and Discussion

The values obtained from Government owned water supply schemes (GWSS) for TDS and EC are shown in Figure 3, and Private owned dug well schemes (PDWS) are given in Figure 4. The maximum TDS from GWSS was found as sample G-1 with 10656 mg/l while second, third, fourth and fifth maximum

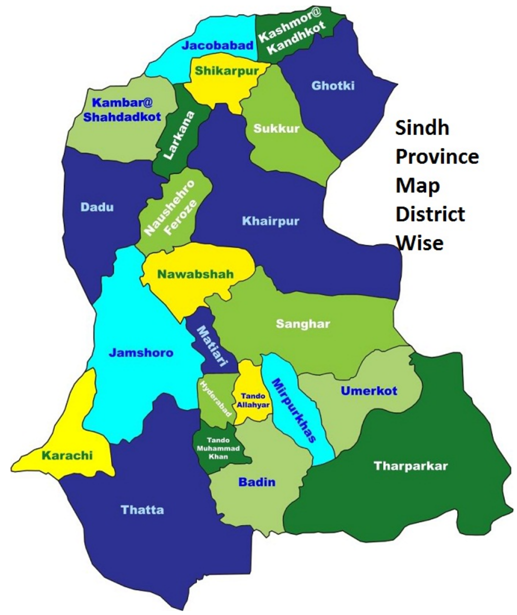

Fig. 1: Location of District Tharparkar in Sindh Province

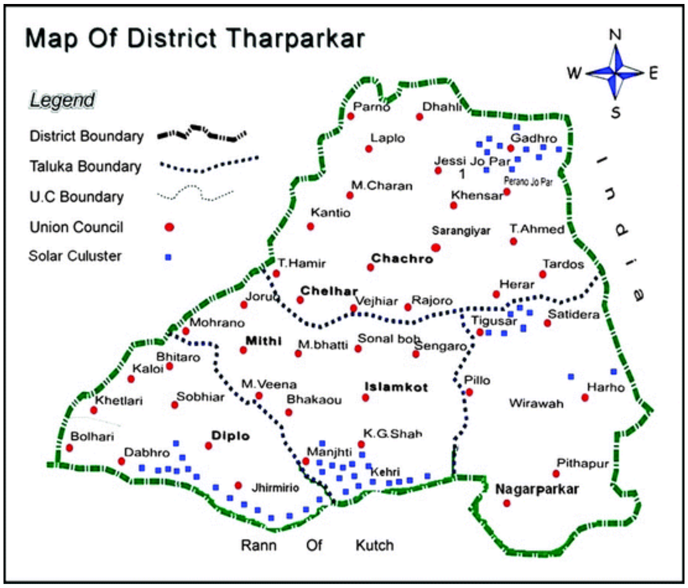

Fig. 2: Location of Taluka Chachro in District Tharparkar [16]

values were recorded from G-14, G-15, G-16, and G-11 with 8185 mg/l, 7513 mg/l, 7462 mg/l, and 7200 mg/l respectively.

The minimum value of TDS was observed in G-2 with 766 mg/L. Similarly, the maximum electrical conductivity (EC) was observed from sample G-1 with 16650 μS/cm, and minimum from G-2 with 1197 μS/cm. It can be seen from the analysis that all values of electrical conductivity showed similar trend as that of total dissolved solids. On the other hand, from dug wells owned by private people, the maximum TDS was found from the sample P-6 with 29152 mg/l and minimum from P-3 with 2476 mg/l. Similarly, maximum EC from sample P-6 with 45550 μS/cm and minimum from sample P-3 with 3870 μS/cm.

The values obtained from Government owned water supply schemes for pH and water temperature (T) are shown in Figure 5 and private owned dug well schemes are shown in Figure 6. Maximum pH of the samples taken from government owned water units was noted from the sample G-7 with 8.4 and minimum from G-11 with 6.6. No major change in pH and temperature was reported from different locations of both GOWSS and PODWS. Maximum pH of samples taken from dug wells were found from two samples identified as P-3 and P-6 with 7.6, and minimum from sample P-4 with pH of 7.2. Moreover, the maximum temperature of samples taken from government owned water bodies was observed from sample G-12 with 36.1°C, and minimum from sample G-19 with 30.8°C. Similarly, maximum temperature of dug well samples was noted

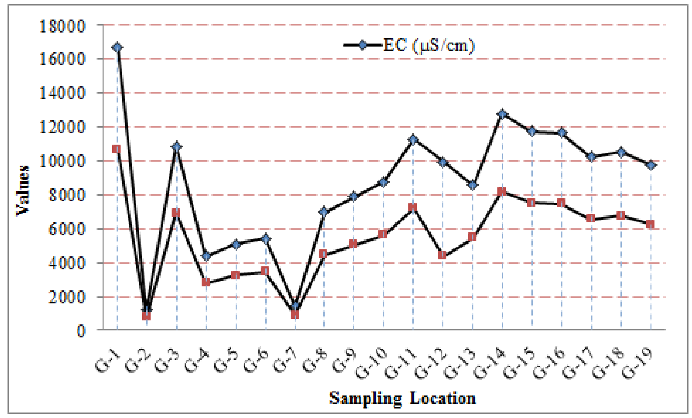

Fig. 3: TDS and EC of government owned water supply schemes

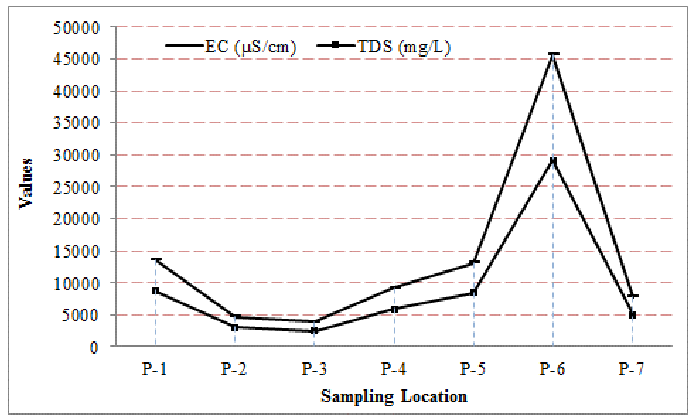

Fig. 4: TDS and EC of private owned water supply schemes

from P-6 with 34.7°C, and minimum from P-1 with 31.2°C. It is because samples taken in different timing, therefore different pH and temperature were recorded. In addition, a correlation study of TDS and EC was conducted by using Pearson Correlation. The analysis revealed that there is strong correlation between total dissolved solids (TDS) and government owned with a correlation of 0.983 and 01.

4 Conclusion

It is revealed from the analysis of examined groundwater samples that the amount of both total dissolved solids (TDS) and electrical conductivity of Taluka Chachro is very high from the standards set by World Health Organization (WHO). Thus, the groundwater is not good for human as well as livestock without any prior treatment for reduction of TDS and EC. The regular consumption of this groundwater may increase various health anomalies in people, including kidney stones, joint pains, etc. Strong correlation between total dissolved solids (TDS) and electrical conductivity

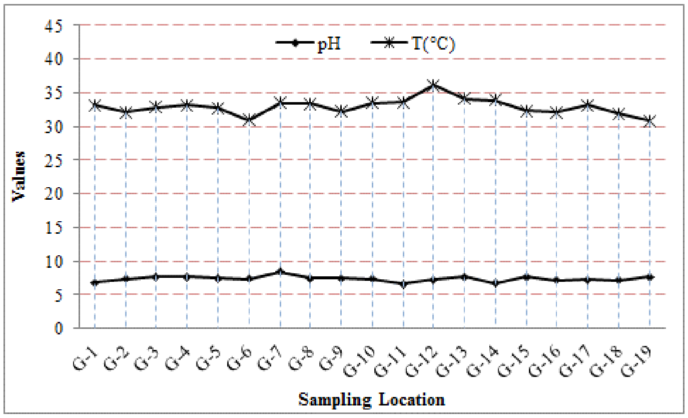

Fig. 5: Sampling time pH and water temperature of Government Owned Water Supply Schemes

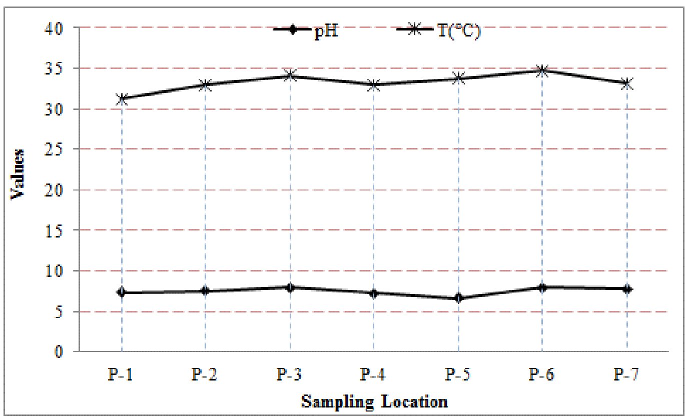

Fig. 6: Sampling time pH and water temperature of Private Owned Water Supply Schemes

(EC) was found both from the government as well as private owned water supply scheme with 0.983 and 1.0, respectively. Moreover, no deviation of water temperature and pH was observed than WHO guidelines values in all examined water samples. On the basis of present observations, further study could be carried out to make actual correlation between TDS and EC. On the basis of our present observation, there arises a provision to investigate the actual relation between these two parameters (TDS and EC). This should have the need of some further analysis of water of these water bodies and a detailed study of these parameters.

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