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ASSESSMENT OF WATER QUALITY PARAMETERS OF MAVADI KULAM AND ITS SURROUNDING BORE WELL WATER SAMPLES, PONMALAIPATTI, TIRUCHIRAPPALLI (DT), TAMIL NADU, INDIA

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AUTHOR'S CONTRIBUTION

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ABSTRACT

This paper deals with an assessment of water quality parameters of Mavadi Kulam and its surrounding bore wells, Ponmalaipatti, Tiruchirappalli (dt). In the case of Mavadi Kulam water samples, the mean value of pH, Electrical conductivity, Total Hardness, Magnesium Hardness, Phosphate, Silicate, and DO was within the permissible limit and Calcium Hardness was within the desirable limit. The low level of BOD of Mavadi Kulam water samples indicates higher water quality. The results reveal that the Mavadi Kulam water does meet the drinking water standards and is fit for drinking and domestic purposes. Some parameters of bore well water samples such as Electrical conductivity, Total Hardness, Calcium Hardness, Sodium, and Potassium were higher than the Permissible limit. These results reveal that the groundwater does not meet the drinking water standards and it should be treated for people's health and environmental safety.

Keywords: Mavadi kulam; ponmalaipatti; tiruchirappalli; water quality parameters; groundwater.

1. INTRODUCTION

Water plays an essential role in all forms of life and it is an important requirement for human beings. Water has many nutrients and minerals and is of primary importance in human life [1]. Apart from drinking and cleaning water also used for recreation, human beings pursue water's edge such as a solvent, cleaner, coolant, a compound from which every organism is created. So, pollution of water is considered a global concern. Water pollution can be caused by extraordinary urbanization and modernization. The problems of groundwater quality are more acute in the areas which are densely populated and thickly industrialized. Once the groundwater is polluted, its purification is too difficult. In the past few years, strict regulations and control have increased rapidly in monitoring surface water bodies due to deteriorating environmental concerns. The quality of the lake water is dependent on the geological structure of the earth and also on the human activities surrounding it [2,3,4,5,6] as these destroy the potential use of water [7].

The surface water bodies such as lakes, rivers, and springs are important sources of freshwater [8]. The insufficiency in the surface water resources makes the people dependent on the groundwater for the regular water supply. So, the unavailability of surface water in all places and scarcity of the same, groundwater is

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used for domestic, agriculture, and industries in rural and urban places. It has inherent advantages over surface water. Agriculture is one of the greatest users of water accounting for 80% of all consumption. Approximately it takes 1000 tons and 2000 tons of water to grow one ton of grain and one ton of rice respectively. The present irrigated area in India is 60 million hectares of which about 40% is from groundwater because there has been a great increase in the demand for freshwater due to overgrowth in population and industrial usage. Next to agriculture, Animal husbandry and fisheries require abundant water. The rapid growth of urbanization has affected the quality of groundwater, due to over-exploitation of recourse and improper waste disposal. So, it is important to assess the quality of groundwater [9,10]. Worldwise almost one-fifth of all the water is obtained from groundwater [11]. So, we should concentrate on the quality of groundwater, but it is directed by our activities. The quality of Groundwater, particularly, the concentration of dissolved ions, solids, and minerals, is directed by groundwater flow, geochemical reactions, the solubility of salts, and anthropogenic activities [12,13,14,15]. Due to anthropogenic pressure, during the last several decades, there is a change in the Earth and Ecosystem and it is consuming ever-increasing amounts of freshwater. Its availability at a spot is largely predetermined by both climatic and geological conditions. Nowadays people use rivers as a carriage [16]. When alternative sources are available the groundwater quality studies are not critical. In many places, especially, hut dwellers have no option so, they are using shallow wells for their water requirement. These shallow wells are the only source for them. So, groundwater is the principal source of drinking water in rural areas of India and it is an indispensable source of life.

Groundwater is a precious and the most widely distributed resource of the earth. Groundwater is one of the largest sources of fresh water on our planet excluding the polar ice caps and glaciers. But, at present nearly one-fifth of all the water used in the world is obtained from groundwater resources. So, in the world, the production and management of groundwater quality are emerging as a great public concern in India and other countries.

The water quality is defined on the physicochemical parametric values determined [17]. The variations in Physico-chemical properties fluctuate on both temporal and spatial scales [18,19]. These parametric values reveal the present status of the water body and the prolonged evaluations of these parameters can easily describe the hydrological modifications taking place in the water bodies [20]. If these chemical compositions are within permissible limits, the water is safe to drink. Generally, the groundwater quality is good but the recharged water contains pollutants, and these pollutants are dissolved in groundwater and pollute it [21]. Pollutants in groundwater affect its usage [22] and when drinking this kind of polluted water, it causes about 80% of diseases and one-third of death in developing countries [23,24]. The presence of too many chemical elements is harmful.

It is necessary to study the groundwater quality by assessing the chemical composition of the water. Most groundwaters contain 95% of ions such as Na+, K+, Ca2+, Mg2+, Cl-, So4-, HCO3- and NO3-. Adding together these ions are responsible for the salinity of groundwater and hence called total mineralization. The chemical concentration of some of the ions has an impact on the quality of groundwater. They are Ca, Mg, Na, K, Cl, Co3, HCo3, SO4, PO4, H4SiO4. If the mineral content of water is high, it is referred to as hard water, which is determined by the level of multivalent cations (Ca2+ and Mg2+) in water and this may be due to sedimentary rocks and runoff from soil [25]. High concentrations of Ca2+ and Mg2+ are responsible for the accumulation of insoluble salt deposits in storage tanks or plumbing. Natural water gets contaminated due to weathering of different types of rocks, leaching of soils, and mining processing. Therefore, the treatment of groundwater is not so easy as compared to surface water because the elements influencing water quality are not easily known.

The quality of water can be assessed by various parameters such as pH, BOD, COD, electrical conductivity, nitrate, phosphorus, potassium, DO, etc. It is also pointed out by heavy metals such as Pb, Cr, Fe, Hg, etc. because they affect water and make it chronic poisoning in aquatic animals.

Tiruchirappalli is one of the most important industrial cities in Tamil Nadu and is sited on the bank of the River Cauvery. In this study, an attempt has been made to assess the water quality of the Mavadi Kulam and its surrounding bore wells at Ponmalaipatti in the Trichy district. This study has made a systematic approach to get an idea about physiochemical parameters of the surface and groundwater present in the study area.

2. MATERIALS AND METHODS

2.1 Study Area

Mavadi Kulam is a small shallow puddle of water. it is situated in Ponmalaipatti, Trichy. It is spread over 140 acres.

Mavadi Kulam Latitude: 10° 46' 27" North

Mavadi Kulam Longitude: 78° 44' 0" East

City: Tiruchirappalli

State: Tamil Nadu

Country: India

Known Place: Thirunagar

2.2 Sample Collection

The water samples were collected from Mavadi Kulam and its surrounding five different borewells in the study area. One liter of water sample was collected by polythene bottles from various parts of the pond and five different borewells in its surrounding during September 2021 for analysis of various chemical parameters.

Fig. 1. Satellite image of Mavadi Kulam

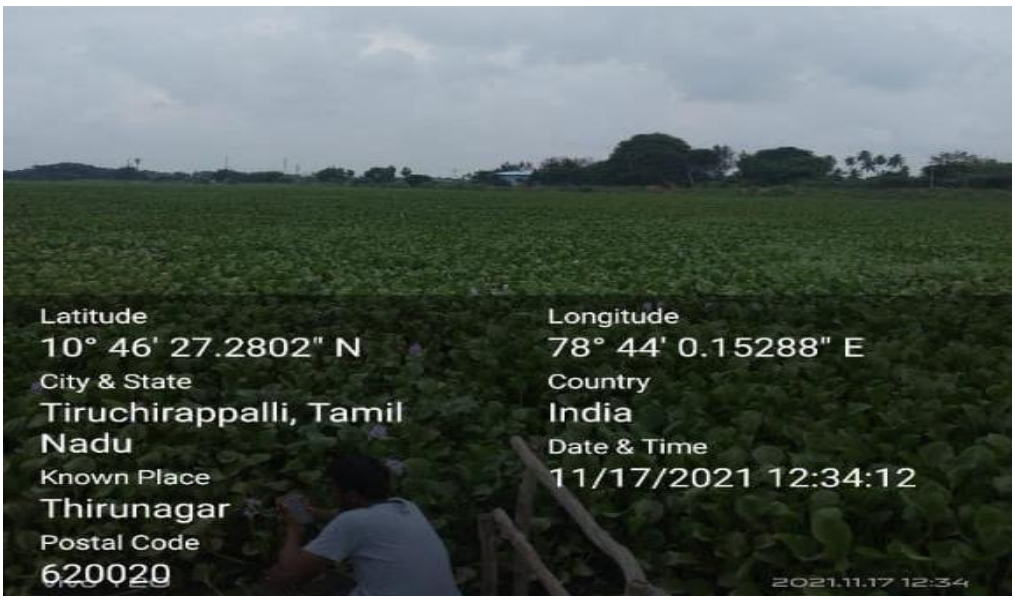

Fig. 2. Mavadi Kulam

Fig. 3. Water samples collected from Mavadi Kulam

Fig. 4. Water samples collected from different borewell

2.3 Chemical Parameters

pH was measured by portable pH meter, the electrical conductivity of the water was determined by conductivity meter, then TDS was done by calculation method, Total Hardness was estimated by the titrimetric method. Calcium Hardness and Magnesium Hardness were analyzed by volumetric method, Total Alkalinity and Chloride were estimated by titrimetric method, Nitrate estimated by turbidity method, Fluoride was determined by potentiometric method, Phosphate was analyzed by spectrophotometry method, Silicate was analyzed by colorimetric method, Sodium and potassium were analyzed by flame photometry, DO was analyzed by titration method, BOD was analyzed by photometric method, COD was analyzed by colorimetric method. These are the most important parameters which show the quality of water. These parameters are interrelated to each other and therefore affect the overall quality of lake water Table 1. This shows the significance of the parameters which have been analyzed in this study.

Table 1. Water quality parameters and their effects on water quality

Parameter	Effect
Ph	It indicates the chemical conditions of a solution
Electrical conductivity	It indicates the amounts of dissolved substances, chemicals, and minerals found in water and it serves as an indicator of water quality problems
TDS	It shows the level of pollutants in water bodies.
Total Hardness	It is caused by polyvalent metallic ions dissolved in water, which are principally Mg and Ca. Its adverse effects are economic loss to water.
Calcium Hardness	It indicates water hardness, also function as a pH stabilizer
Magnesium Hardness	It indicates hardness and a necessary constituent of chlorophyll.
Total Alkalinity	It indicates all bases in water and can be thought of as the buffering capacity of water.
Chloride	It increases the electrical conductivity of water. Hence it increases corrosivity
Nitrate	It increases the productivity of lakes
Fluoride	It causes the most important toxicological hazards.
Phosphate	It increases the productivity of lakes
Silicate	It can be beneficial or cause treatment problem
Sodium	It is used in water treatment including softening, disinfection, corrosion control, pH adjustment
Potassium	It conducts electricity. It produces positively charged ions when dissolved in water.
DO	The dissolved oxygen affects the availability of nutrients.
BOD	Its level indicates the number of biodegradable wastes in water.
COD	It measures the number of oxidizable pollutants found in water.

3. RESULTS AND DISCUSSION

Surface water samples were collected from 5 different sites of Mavadi Kulam, Ponmalaipatti, Trichy town. Groundwater samples were collected from 5 bore wells around Mavadi Kulam, Ponmalaipatti, Trichy town. The sampling stations are represented as S1 to S5. The water samples were collected in one-liter polythene bottles. Then the samples were subjected to physiochemical analysis. Determination of water quality parameters of groundwater is essential for the sustainability of drinking water.

pH, Electrical conductivity, Total Hardness, Calcium Hardness, Magnesium Hardness, Phosphate, Silicate, and DO of water samples of Mavadi Kulam are within the permissible limit. The concentration of Fluoride and BOD of Mavadi Kulam water samples are slightly below the Desirable limit and TDS, Total Alkalinity, Chloride, Nitrate, and COD are highly below the Desirable limit. Sodium and Potassium levels are above the Permissible limit (Table 2).

pH, Magnesium Hardness, Chloride, Phosphate, Silicate, and DO of borewell water sample are within the Permissible Limit. Fluoride level is very slightly below the Desirable limit. Electrical conductivity, Total Hardness, Calcium Hardness, Sodium, and Potassium are higher than the Permissible limit.

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In water, the pH value is an important factor in maintaining the carbonate and bicarbonate ions levels. In this present study, the pH values are found to be within the permissible limit of WHO (6.5–8) [26] in all the sampling stations for both surface water (Mavadi Kulam) and groundwater samples. There are no abnormal changes. The slight alkalinity may be due to the presence of bicarbonate ions, which are produced by the free combination of CO2 with H2O from carbonic acid, which affects the pH of the water [27]. The Carbonic acid dissociates partially to produce H+ and bicarbonate ions [28]. pH decreases with an increase in temperature and which leads to a negative effect on aquatic plants and animals. at a particular pH, the dissolution of salts and chemicals in water is possible. The mild alkalinity indicates the presence of weak basic salts [29]. But the low pH does not cause any harmful effects.

Table 2. Parameters studied in Mavadi Kulam water samples

Parameter	S1	S2	S3	S4	S5	Mean±Std.dev	Desirable limit	Permissible Limit
pH	7.23	7.69	7.25	7.37	7.38	7.38±0.18	6.5-8.5	No relaxation
Electrical conductivity (micro mho cm^{-1})	390.0	280.00	290.00	310.00	350.00	324.00±45.60	192	600
TDS (mg/l)	195.00	140.00	155.00	169.00	190.00	169.8±23.18	500	2000
Total Hardness (mg/l)	315.00	335.00	330.00	328.00	318.00	325.2±8.40	300	600
Calcium Hardness (mg/l)	104.20	72.14	80.00	92.00	74.02	84.47±13.48	75	200
Magnesium Hardness (mg/l)	13.36	37.66	20.42	36.14	15.90	24.69±11.43	30	50
Total Alkalinity (mg/l)	60.00	30.00	50.00	55.00	35.00	46.00±12.94	200	600
Chloride (mg/l)	159.52	63.81	78.01	75.90	158.95	107.24±47.77	250	1000
Nitrate (mg/l)	3.00	6.20	3.00	6.02	5.59	4.76±1.62	45	100
Fluoride (mg/l)	0.44	0.32	0.31	0.50	0.38	0.39±0.08	1.0	1.5
Phosphate (mg/l)	0.10	0.09	0.12	0.13	0.07	0.10±0.02	-	0.1
Silicate (mg/l)	5.20	12.40	7.69	9.96	6.58	8.37±2.84	5	25
Sodium (mg/l)	78.40	92.60	82.60	90.79	79.40	84.76±6.55	30	60
Potassium (mg/l)	17.20	33.20	22.00	15.95	18.84	21.44±6.95	0.4	12
DO (mg/l)	8.60	6.72	6.70	7.62	8.63	7.65±0.95	6.5	8
BOD (mg/l)	4.33	3.36	4.58	3.13	4.37	3.95±0.65	5	30
COD (mg/l)	52.00	36.00	40.65	47.25	41.96	43.57±6.18	120	250

Table 3. Parameters studied in borewell water samples

Parameter	S1	S2	S3	S4	S5	Mean±Std.dev	Desirable limit	Permissible Limit
Ph	7.12	7.04	7.06	7.09	7.11	7.08±0.03	6.5-8.5	No relaxation
Electrical conductivity (micro mho cm^{-1})	976.00	939.00	955.00	940.00	962.00	954.4±15.56	192	600
TDS (mg/l)	488.00	469.00	470.00	461.00	482.00	474.00±10.83	500	2000
Total Hardness (mg/l)	750.00	715.00	720.00	734.00	718.00	727.4±14.58	300	600
Calcium Hardness (mg/l)	226.45	224.44	222.41	221.43	220.42	223.03±2.42	75	200
Magnesium Hardness (mg/l)	44.95	37.66	40.67	39.72	36.82	39.96±3.18	30	50
Total Alkalinity (mg/l)	90.00	100.00	92.00	91.00	95.00	93.6±4.03	200	600
Chloride (mg/l)	549.47	581.38	551.32	561.34	572.46	563.19±13.68	250	1000
Nitrate (mg/l)	2.70	2.60	2.62	2.65	2.68	2.65±0.04	45	100
Fluoride (mg/l)	0.64	0.63	0.69	0.74	0.72	0.68±0.04	1.0	1.5
Phosphate (mg/l)	0.04	0.08	0.09	0.02	0.07	0.06±0.02	-	0.1
Silicate (mg/l)	8.40	14.00	9.50	8.43	7.62	9.59±2.55	5	25
Sodium (mg/l)	236.10	233.30	244.09	222.08	220.13	231.14±10.00	30	60
Potassium (mg/l)	38.60	48.20	46.50	45.23	39.34	43.57±4.34	0.4	12
DO (mg/l)	6.52	7.12	6.72	6.43	6.22	6.60±0.34	6.5	8
BOD (mg/l)	3.26	3.22	3.23	2.50	3.24	3.09±0.33	5	30
COD (mg/l)	24.00	32.00	27.00	22.00	30.00	27.00±4.13	120	250

To carry an electrical current the Electrical conductivity of water is important and the importance of electrical conductivity is its measure of salinity, which greatly affects the taste of water and has a significant impact on the user acceptance of the water as potable [30]. The greater electrical conductivity indicates the higher ionizable salts. Higher electrical conductivity affects the germination of crops and it may result in much-reduced yield [31]. The WHO permissible limit for electrical conductivity of water is 600 micro mho cm–1. In this present study, the electrical conductivity values observed in the Mavadi Kulam water samples were within the permissible limit (324.00±45.60), but it is in a higher range in bore well water samples (954.4±15.56). This higher range indicates the presence of a high amount of dissolved inorganic substances, ionic constituents, and dissolved minerals in the water samples [32].

The TDS of Mavadi Kulam and bore well water were 169.8±23.18 and 474.00±10.83 respectively. Hence the value of total dissolved solids for both the surface and the groundwater samples are below the desirable limit in this present study. Total dissolved solids represent various types of minerals present in the water in the dissolved form. But most of the groundwater samples show higher values of total dissolved solids and are well above the permissible limit of 500 mg/l [33].

Total hardness revealed the presence of divalent metallic cations, of which Ca and Mg are the most abundant in groundwater. It is also delivered from a solution of CO2, released by bacterial action in the soil, in percolating rainwater. Hardness value below 300 mg/l is considered as potable water [34]. In this present study, the total hardness values were within the permissible limit (325.2±8.40) in Mavadi Kulam, but the Total hardness value exceeded the desirable limit in all the stations for bore well water samples (727.4±14.58). This may be due to the presence of some ions such as bicarbonates, chlorides, and sulfates of calcium and magnesium present in the water. The highest concentration of hardness may cause heart disease and kidney problems [35].

The permissible limit of Calcium hardness is 75- 200 mg/l BIS [33]. The value of calcium hardness of water samples was below the desirable limit (84.47±13.48) in Mavadi Kulam and above the permissible limit (223.03±2.42) in borewells at all sites. Calcium may dissolve readily from calamite rocks and limestone or it may be leached from soils. However, calcium is an essential nutritional element for human beings and aids in maintaining the structure of plant cells and soils.

The magnesium hardness values are found below the desirable limit (24.69±11.43) in Mavadi Kulam water samples and within the permissible limit (39.96±3.18) in bore well water samples. If magnesium hardness exceeds the permissible limit, it indicates the discharge of the sewage and dissolution and rock weathering of a soil in rainy seasons [36] and unsuitable for domestic uses.

Total Alkalinity is below the desirable limit in both Mavadi Kulam (46.00±12.94) and bore well (93.6±4.03) water samples. If it is too low it relates to a high level of acidity.

The mean value of chloride was below the desirable limit in Mavadi Kulam (107.24±47.77) and within the permissible limit in bore well (563.19±13.68) water samples. If excess chloride of greater than 250 ppm gives a salty taste to water. Excessive chloride in potable water is particularly not harmful but its excessive level leads to high corrosiveness. Chloride concentration is dependent on soil porosity and permeability [37]. The high concentration of chloride level is considered to be an indicator of pollution by the organic waste of animals and industrial origin [30]. Higher levels of chloride in water are injurious to people who have heart and kidney diseases.

The nitrate values were much below the desirable limit in both surface (Mavadi Kulam) and groundwater (bore well) of the study area. Nitrate is a naturally occurring compound and has many human-made sources. This compound is responsible for the growth of blue-green algae in water [29]. We cannot taste or smell the nitrate that is found in water. Consuming too much nitrate can be harmful to children. Levels of nitrate at or below 10 mg/L are considered safe to drink for everyone [38].

The fluoride values for both Mavadi Kulam (0.39±0.08) and the groundwater samples (0.68±0.04) were below the desirable limit. If it is high in groundwater, it may be due to the breakdown of rocks and soils or filtration of chemical fertilizers from agricultural land and it causes skeletal fluorosis [39].

In the present study, the phosphate values are found within the permissible limit in both surface (0.10±0.02) and groundwater samples (0.06±0.02). So, the phosphate values of water samples in the study area do not pose any water quality problem. Usually, groundwater contains a minimum level of phosphorus because native phosphate is soluble slowly and the low ability of soils to retain phosphate [40].

Silicate of both surface (8.37±2.84) and groundwater (9.59±2.55) in the study area was within the permissible limit of WHO [41]. Silicate is responsible for the growth of algae. So, increased silicate levels will affect the water ecosystem.

The sodium values are found to be high in both surface (84.76±6.55) and groundwater samples (231.14±10.00) of the study area. The Higher concentration of sodium may be due to the discharge of effluents into the water [42] and percolation of saltwater water of irrigational and industrially used water [43].

The potassium values were high in both surface (21.44±6.95) and groundwater samples (43.57±4.34) of the study area. A high concentration of potassium is due to the discharge of contaminated sewage wastewater [44].

DO is considered an important water quality parameter. It directly supports aquatic life. Even though each organism has its own DO tolerance level, generally, DO levels below 3mg/L are of concern. If the DO level of waters is below 1 mg/L, which is considered hypoxic and usually devoid of life [45]. In this present study the mean level of DO in Mavadi Kulam (7.65±0.95) and bore well (6.60±0.34) water samples were found to be within the permissible limit.

Biochemical oxygen demand (BOD) represents the amount of oxygen consumed by microorganisms while they decompose organic matter under aerobic conditions at a specified temperature. BOD is the amount of oxygen required to remove waste organic matter from water through the process of decomposition. For decomposition bacteria need oxygen to do their work. Hence, there is a demand in the level of Oxygen [46]. Higher BOD indicates more oxygen is required and signifies lower water quality which is less for oxygen-demanding species to feed on. Contrariwise, the low level of BOD indicates less oxygen is required and signifies higher water quality. Unpolluted rivers usually have BOD levels below 1 ppm, while untreated sewage has between 200 and 600 ppm [47]. In this present study the mean value of BOD was found to be within the desirable limit in both surface (3.95±0.65) and groundwater (3.09±0.33) of the study area.

Chemical oxygen demand (COD) must be present in water to oxidize chemical organic materials, that is it chemically break down pollutants. Though the treated wastewater is discharged into the environment, it can introduce pollution in the form of organic content. A high level of wastewater COD indicates concentrations of organic content that can deplete dissolved oxygen in the water, it affects the environmental and regulatory consequences. If the COD levels are higher, there is a greater oxygen demand. So, it is necessary to reduce the level of COD, thus increasing the DO level [48]. In this present study, the mean value of COD was found to be below the desirable limit in mavadi Kalam (43.57±6.18) and bore well (27.00±4.13) water samples. So, there is no demand for DO in water samples of study areas.

4. CONCLUSION

Mavadi Kulam water does meet the drinking water standards and is fit for drinking and domestic purposes. In the case of bore well water samples high concentrations of Electrical conductivity, Total Hardness, Calcium Hardness, Sodium, and Potassium are higher than the Permissible limit. The results reveal that the groundwater does not meet the drinking water standards and is unfit for drinking and domestic purposes. This problem should be attended to and controlled at the earliest for the sake of people's health, environmental safety, and water quality because once the groundwater is polluted, it is difficult to restore it to its initial quality.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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