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Groundwater Quality of Mayiladuthurai City During Monsoon 2008, Tamil Nadu, India.

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ABSTRACT

In developing countries boreholes are economically viable option for water production and supplies for domestic and general use. Groundwaters are generally considered as 'safe sources' of drinking water because they are produced with low microbial load with little need for treatment of the water before drinking. A physicochemical and microbial analysis of drinking water from six (6) different boreholes on the campus of the Kwame Nkrumah University of Science and Technology (KNUST) and two of its satellite communities; Ayeduase and Kotei was undertaken. The principal aims were to ascertain the wholesomeness of the water by assessing the level of microbes as well as the faecal matters and total coliform and to determine and compare the levels of major elements in the water with international standards. All the water samples passed the physical and chemical tests conducted, except for the pH test which most of the samples failed. The levels of trace metals determined were all below the WHO guideline levels. Only Unity Hall Borehole, UHB and Ayeduase Borehole 1, AB1 failed the microbial test using Mannitol Salt Agar and Bismuth Sulphite Agar respectively. With the exception of the control, all the water samples failed the total and true coliform test.

INTRODUCTION

About 50% of all the underground water used in urban areas of developing countries is derived from wells and boreholes and many inhabitants in India also rely on such resources. The quality of water is more important than quantity in any water supply. The physical, chemical characteristics of ground water determine its usefulness for municipal, agricultural and domestic water supplies. Mayiladuthurai is one of the fastest growing cities in the country which is undergoing rapid urbanization and industrialization. Urbanization has led to immense pressure on groundwater resources.

MATERIALS AND METHODS

A total number of 20 sampling stations were selected all over the study area in and around Mayiladuthurai and water samples were collected during monsoon of 2008 (October, November and December). Sampling and analysis were using APHA ^[1]. All the villages under the study area are depending groundwater for drinking purpose. All precautions were taken during collection and handling of samples. The groundwater samples were collected in polythene containers. The pH, electrical conductivity was determined on the spot using digital equipments after sampling. Water samples were analyzed for

chemical parameters such as Total Dissolved Solids, Total hardness, Sodium, Potassium, Calcium, Magnesium, Chloride, Sulphate, Nitrate and Fluoride.

RESULTS AND DISCUSSION

The details of ground water sampling stations in the study area were given in Table 1. Various physico-chemical parameters were studied and given in Table 2. The analytical results of physical and chemical parameters of ground water were compared with the standard guideline values as recommended by the World Health Organization (1971, 1985 WHO) for drinking and Public health purposes (Table 3).

Table 1: Details of ground water sampling stations in the study area

Sl. No	Sampling stations	Source of water
S-1	Kuthalam	Open well
S-2	Sethrabalapuram	Bore well
S-3	Arayapuram	Bore well
S-4	Malliyam	Bore well
S-5	Mahadhanapuram	Bore well
S-6	Moovalur	Bore well
S-7	Sitharkadu	Bore well
S-8	Mayiladuthurai Pookadai Street	Bore well
S-9	Mayiladuthurai Koranadu	Bore well
S-10	Mayiladuthurai Mahadhana Street	Bore well
S-11	Thiruvazhandur	Bore well
S-12	Mayiladuthurai Coconut tree street	Bore well
S-13	Senthangudi	Bore well
S-14	Nagangudi	Bore well
S-15	Lakshmpuram	Bore well
S-16	Uluthukuppai	Bore well
S-17	S.S. Nallur	Bore well
S-18	Thirunanriyur	Bore well
S-19	Keezha Athukudi	Bore well
S-20	Mela Athukudi	Bore well

Table 2: Statically data of various physico chemical parameters of the study area during Monsoon season of 2008.

Sl.No	Parameters	Unit	Min	Max	Mean	Median	SD	CV
1.	pH	-	7.14	7.69	7.44	7.44	0.166966	0.022435
2.	EC	dS/cm	0.36	0.82	0.51	0.51	0.117531	0.232044
3.	TDS	mg/l	228.33	527.33	324.22	326.50	75.24885	0.232094
4.	TH	mg/l	206.07	381.99	305.00	302.95	48.77619	0.15992
5.	Sodium	mg/l	18.00	40.00	28.86	27.83	6.858289	0.237654
6.	Potassium	mg/l	0.12	0.23	0.16	0.16	0.03111	0.190661
7.	Calcium	mg/l	38.00	85.20	65.10	66.00	11.42758	0.175539
8.	Magnesium	mg/l	25.10	45.30	34.59	33.22	6.028489	0.174276
9.	Chloride	mg/l	56.00	120.40	82.74	80.17	16.81105	0.203171
10.	Sulphate	mg/l	20.67	71.00	42.79	44.00	15.26407	0.356721
11.	Phosphate	mg/l	0.02	0.03	0.03	0.03	0.005084	0.198081
12.	Nitrate	mg/l	0.26	0.61	0.39	0.34	0.111435	0.282951
13.	Fluoride	mg/l	1.98	3.05	2.40	2.40	0.321447	0.133788

(EC – Electrical conductivity, TDS – Total dissolved salts, TH – Total hardness)

Table 3: WHO International Standard of Drinking water.

Parameters	Most desirable limit	Maximum allowable limit
pH	7-8.5	9.2
Total Dissolved Solids(mg/l)	500	1500
Total Hardness (mg/l)	100	500
Sodium (mg/l)	-	200
Calcium (mg/l)	75	200
Magnesium (mg/l)	50	150
Chloride (mg/l)	200	600
Sulphate (mg/l)	200	400
Nitrate (mg/l)	45	-
Fluoride (mg/l)	-	1.5

pH and Electrical Conductivity

The pH values of groundwater ranged from 7.14 to 7.69 shown that the groundwater of the study area is mainly alkaline in nature. The electrical conductivity value ranged from 0.36 dS/cm to 0.82 dS/cm, is within the desirable limit.

Total Dissolved Solids

TDS is sum of the cations and anions concentration. A high content of dissolved solids elevates the density of water, influences osmoregulation of fresh water organism, reduces solubility of gases (like oxygen) and reduces utility of water for drinking [2]. Based on Total Dissolved Solids value present in groundwater, groundwater resources are classified into Fresh water (1000mg/l), Brackish water (1000-10000 mg/l), Saline water (10000-100000 mg/l) and >100000 mg/l Brine water [3,4]. The ground water of the study area is fresh water as per the WHO international standard. The analytical data shown that the most of the study area is below 500 mg/l of TDS except station 15 indicating low content of soluble salt in ground water which can be used for drinking without any risk.

Total Hardness

The Total hardness values ranged from 206.07 mg/l to 381.99 mg/l monsoon of 2008. The maximum desirable limit is 100mg/l as per WHO international standard. All the samples collected during monsoon of 2008 exceeded the desirable limit but within the maximum allowable limit.

Chloride

Chloride is a widely distributed element in all types of rocks in one or another form. Its affinity towards sodium is high. Therefore, its concentration is high in groundwater, where the temperature is high and rainfall is less. Soil porosity and permeability also play an important role in increasing the chlorides concentration [5]. The chloride values ranged from 56 to 120.40 mg/l and all the samples are within the prescribed limit.

Nitrate

The concentration of nitrogen in groundwater is derived from the biosphere. The high concentration of nitrate in drinking water is toxic and causes blue baby disease of methaemoglobinaemia in children and Gastric carcinomas. The nitrate concentration varied between 0.26 mg/l to 0.61 mg/l and no sample is exceeded the desirable limit.

Sulphate

Water containing magnesium sulphate (1000 mg/l) acts as purgative in human adults (Bhagavathi Perumal and Thamarai [6,7]. Sulphate is unstable if it exceeds the maximum allowable limit 400 mg/l and causes a laxative effect on human system with the excess magnesium in ground water. In the present study, all the samples are within the most desirable limit prescribed by WHO and it varied from 20.67 to 71 mg/l.

Phosphate

The phosphate ion concentration varied between 0.02 to 0.03 mg/l. No guideline is proposed to phosphate.

Fluoride

Fluoride is both beneficial and detrimental nutrient for human life. It is important for the integrity (calcification) of bone and teeth. Deficiency or excess of fluoride in the environment is closely associated with human health [8]. Fluoride is often called a double edged sword because deficiency of fluoride intake leads to dental caries while excess consumption of fluoride causes fluorosis[9]. Research has shown that the low level of fluoride concentration (0.5 – 0.75 mg/l) favours dental caries development and teeth resistant to decay. However, mottling of teeth (dental fluorosis) may occur when the concentration increases more than 1.5 mg/l. Long term intake of water containing excessive fluoride concentration in the range of 5 to 10 mg/L causes skeletal fluorosis, in which the bone structure is affected causing bone deformation and crippling. Knock knees (genu valgum) have been reported in adolescents receiving > 10mg fluoride/day, accumulated from birth [10,11,12]. Thus, the Bureau of Indian Standards (BIS) and World

Health Organization (WHO) prescribed a limit of fluoride level between 1.0 and 1.5 mg/l for drinking water quality, whereas USPHS [13] has set a range of allowable concentrations for fluoride in drinking water for a region depending on its climatic conditions because the amount of water consumed and consequently the amount of fluoride ingested being influenced primarily by the air temperature. The concentration of fluoride in groundwater of the study area varied from 1.98 to 3.05 mg/l. The concentration of fluoride is higher in groundwater resources of the study area. The fluoride ion concentration exceeds the maximum allowable limit of 1.5 mg/l as prescribed WHO. Bedrock containing fluoride minerals is responsible for high concentration of this ion in groundwater of the study area. All samples examined exhibit their unsuitability for drinking.

Calcium and Magnesium

Calcium ion concentration of groundwater resources of the study area varied from 38 to 85.20 mg/l and Magnesium ion varied from 25.10 to 45.30 mg/l. According to calcium, magnesium ion concentration of groundwater resources of the study area is suitable for drinking purpose.

Sodium and Potassium

Sodium ion concentration of groundwater resources of study area varied from 18 to 40 mg/l and potassium ion varied from 0.12 to 0.23 mg/l. According to sodium ion concentration all the samples of the groundwater resources were within the desirable limit and no guideline value are proposed for potassium ion.

Statistical Studies

Correlation studies

Correlation co-efficient is commonly used to establish the relationship between the two variables. The correlation matrix for 13 physico-chemical parameters of groundwater samples in the study area was prepared and tabulated in Table 4.

Table 4: Correlation co- efficient values between the water quality parameters of groundwater samples in the study area during Monsoon 2008

	pH	EC	TDS	TH	Na	K	Ca	Mg	Cl	SO ₄	PO ₄	NO ₃	F
pH	1												
EC	0.04	1											
TDS	0.04	0.99	1										
TH	-0.19	0.81	0.81	1									
Na	-0.02	0.59	0.59	0.59	1								
K	0.39	0.11	0.11	-0.17	0.15	1							
Ca	-0.33	0.64	0.64	0.93	0.50	-0.34	1						
Mg	0.01	0.85	0.85	0.90	0.59	0.06	0.67	1					
Cl	0.10	0.65	0.64	0.66	0.63	0.27	0.51	0.71	1				
SO ₄	-0.15	0.70	0.70	0.68	0.65	-0.20	0.66	0.57	0.38	1			
PO ₄	0.01	0.29	0.29	0.01	0.11	0.25	0.05	-0.05	0.11	0.31	1		
NO ₃	0.27	-0.32	-0.32	-0.40	-0.12	0.48	-0.61	-0.10	0.02	-0.55	-0.27	1	
F	0.02	0.45	0.50	0.41	0.20	-0.14	0.53	0.21	0.08	0.64	0.44	-0.64	1

From the Table:4, EC shown strong positive correlation with TDS, total hardness & magnesium and moderate positive correlation with sodium, calcium,sulphate, chloride ,phosphate and fluoride in the study area.

TDS shown strong positive correlation with EC, total hardness & magnesium and moderate positive correlation with sodium,calcium, chloride,sulphate & fluoride.

TDS shown strong positive correlation with EC, total hardness& magnesium indicates that the existence of these ions in the form of CaCl₂,MgCl₂& MgSO₄.

Total hardness shown strong positive correlation with calcium and magnesium and moderate positive correlation with sodium, chloride & sulphate. Sodium shown moderate positive correlation with chloride.

Fluoride shown only moderate positive correlation with TDS,calcium and sulphate. Then, magnesium shown strong positive correlation with total hardness and total alkalinity. The poor relationship of nitrate

with other ions and potassium with other major ions were noticed. Besides, insignificant positive correlation were observed between the following parameters

- EC with potassium (0.11), phosphate (0.29) and fluoride(0.45)
- TDS with potassium (0.11), phosphate(0.39) and fluoride(0.50)
- Chloride with potassium(0.27),and calcium(0.51)
- Sulphate with sodium(0.33)and potassium(0.30)
- Phosphate with sodium (0.11) and potassium(0.25)
- Fluoride with EC(0.45) magnesium(0.21)

CONCLUSION

From the hydro chemical analysis of groundwater in and around Mayiladuthurai of Nagapattinam district is hard, fresh and alkaline in nature. The concentration chloride, nitrate, sulphate, calcium, sodium and potassium did not exceed their recommended limits during Monsoon of 2008 as per the international drinking water standard. But the concentration of fluoride ion exceeded the permissible limit for drinking for all samples throughout the study period. Due to very high concentration of fluoride, the groundwater resources of the study area cannot be used for drinking purpose. And the study area water resources need purification such as defluoridation before using for drinking purpose.

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