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Evaluation of Physico-Chemical and Microbial Properties of Ground Water Recharged through water Harvesting System in Gwalior, MP, India

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Abstract

In present time water shortage throughout the world is a major problem. Rainwater harvesting is one of the solution to the problems of water shortage in arid and semi-arid regions in India. When this water is used for drinking purpose, it is necessary to assess its quality. The purpose of this study was to assess the physico-chemical properties and microbial activity of underground water recharged by water harvesting system in Gwalior, Madhya Pradesh. Underground water samples were collected from different places of Gwalior city and Dabra town in the month of September which was recharged by water harvesting system. The physico-chemical properties such as color, iron pH, total dissolved solid, salinity, electrical conductivity, acidity, alkalinity, chloride, total hardness, calcium and magnesium hardness and microbial activities were studied and analyzed. The results obtained were compared with permissible limits of the drinking water set by Bureau of Indian Standards. It was observed that water samples except sample no. 3 and 4 were within the permissible limit. This shows that water from these sources is safe for drinking purpose.

Keywords: Water harvesting, drinking water, physico-chemical properties, microbial activity.

Introduction

Water is an essential and vital component of our life supporting system. In India primary sources of drinking water are surface water and ground water. The ground water resources are being utilized for drinking, irrigation and industrial purpose. However due to rapid growth of population, urbanization, industrialization and agricultural activities, ground water resources are under stress. Hence deterioration of ground water quantity and quality is taking place due to geogenic and anthropogenic activities[1]. Human beings have not saved and conserved water and its sources. Probably the irresponsible attitude resulted in deterioration of water bodies with respect to quantity and quality both. Now the situation has arrived that even a single drop of water matters a lot.

System of collection of rainwater and conserving for future needs has traditionally been practiced in India. Traditional water harvesting systems were Bewares, step wells, lakes etc. These were the water storage bodies to domestic and irrigation demands. Ground water resource gets naturally recharged through percolation[2,3]. Indiscriminate development and rapid urbanization, resulted in reduced exposed surface for soil and reduced percolation of rain water, hence causing depletion of ground water. Rain water harvesting is an artificial process of augmenting the natural underground water. Broadly there are two ways of harvesting rainwater i.e., Surface run off and Roof top rain water harvesting. A common problem with these systems is that dust and pollutants that accumulate on roof during dry periods are swept into storage tank along with rain water. So these pollutants and microbes can contaminate the water. When this water is used for drinking purpose it is necessary to assess its quality[4]. In the present study the quality of drinking water was assessed in terms of physiochemical and microbial parameters in the month of September 2012.

Material and Methods

Ground water samples were collected in the month of September 2012 from 8 underground bore wells and hand pumps at various locations of Gwalior and Dabra town which are recharged through water harvesting system. The location was chosen as study area because accumulated environmental pollutants and microbes can swept into storage tank along with rain water and can contaminate water. The samples were collected in sterilized bottles and were stored at 4^0C till further investigations. The physico-chemical parameter such as color, pH, salinity, electrical conductivity, alkalinity, acidity, total dissolve solid (TDS), total hardness, Ca and Mg hardness, chloride, total iron were analyzed according to standard methods[5,6].

Microbiological analysis was done as per guidelines[7-9]. Standard plate count technique for total bacterial population and MPN (Minimum portable number) test for Presumptive coli form count was performed on all water samples collected. A microbial count was made to obtain the presence of bacterial population. A water sample containing less than 100 bacteria

per milliliter is considered to be good quality. A total bacterial count was made by calculating the number of colonies appearing per tryptone glucose extract agar plates incubated at 20^0C and 37^0C for 72 and 24 hours respectively to which aliquots of water sample are added[10].

Four sterile Petri plates with the sample amount i.e. two with 1ml and another two with 0.1 ml. Water sample were labeled and water sample was mixed thoroughly by shaking vigorously. Melted and cooled (45-50^{o}C) nutrient agar medium was added to the inoculated plates and inoculums was mixed by rotating the plates for the uniform distribution of organisms. One set of plates were incubated at 20-22^{0}C for 72 hours and second set at 37^0C for 24 hours[4,7].

The plates for appearance of colonies were observed and the number of colonies was counted in all the plates for the two temperatures.

The colonies per milliliter of water sample were calculated by multiplying the number of colonies in the plate by the sample size.

Multiple tube fermentation test or Most Probable Number (MPN) Test is the most often used technique for the sanitary analysis of water. The test is performed sequentially in three stages; presumptive, confirmed and completed test.

In presumptive coli forms test 10ml of water sample were inoculated aseptically in 5 double-strength lactose broth tubes, 1ml and 0.1 ml of water sample were inoculated in 5 single-strength broth tube separately. All the 15 inoculated tubes are incubated aerobically at 35^0C for 48 hours. All the lactose fermentation tubes were examined for the production of acid (yellow colour) and gas after 24 and 48 hours of incubation. Production of acid (colour change) and gas (appearance of a bubble large enough to fill the concavity at the top of Durham tube) after 24 hours incubation indicates a positive presumption test for coli form bacteria. If gas develops in tubes after 48 hours incubation, the presumptive test is doubtful and if there is no gas produced after 48 hours incubation, it shows negative presumptive test (i.e., coli form absent). The numbers of tubes showing the positive presumption test were recorded. The tubes showing positive presumptive test are retained and used for confirmed test. Confirmed *E. coli* count was determined by preparing some subcultures from all the bottles. The media used were Macconkey agar and Eosin Methylene Blue agar; the sub-cultures were incubated at 37^{o}C and 44^{o}C and examined after 24hours. Besides this each sample was inoculated on Salmonella-Shigella (SS agar) agar plates[11]. The isolates were identified by morphological and biochemical tests viz. colony morphology, Gram staining and motility, Indole, Citrate, Urease, Methyl red, Voges Prosker (VP), Hydrogen Sulphite and sugar fermentation tests. The results obtained were compared with drinking water quality guidelines by Central Public Health and Environmental Engineering Organization CPHEEO[6] and standards set by the Bureau of Indian Standards[12].

On the basis of classification, the nature of ground water has been categorized as desirable, permissible and fit or unfit for human consumption.

Results and Discussion

The physico-chemical and microbial qualities of the underground water near the rain water harvesting plants were determined and the results obtained are shown in table 1.

Table-1
Physico-chemical analysis of water

Sample No.	Color	pH	TDS mg/L	Electrical Conductivity µs/cm	Total Hardness mg/L	Ca mg/L	Mg mg/L	Alkalinity mg/L	Cl mg/L	Fe Mg/L
1.	Transparent	7.83	394.0	486.0	300.66	216.04	84.62	350.0	90.10	0.2
2.	Transparent	8.03	369.0	428.0	280.95	161.10	119.85	390.0	80.60	0.1
3.	Transparent	6.98	225.0	248.0	170.94	122.84	48.10	150.0	47.02	0.08
4.	Transparent	7.69	402.0	440.0	238.09	163.34	74.75	340.0	64.21	0.08
5.	Transparent	7.27	350.0	410.0	340.06	286.04	54.02	310.0	70.54	0.3
6.	Transparent	7.79	330.0	397.0	290.10	160.14	129.96	350.0	30.60	0.1
7.	Transparent	8.01	411.0	345.0	325.20	180.50	144.70	370.0	64.40	0.1
8.	Transparent	7.96	375.0	386.0	330.54	200.40	130.14	350.0	50.55	0.2

1. R.I. Gwalior 2.Bal Bhavan Gwalior 3.Morar Nagar, 4.M.P.E.B. Office (Roshini Ghar) Gwalior 5.Chinis ki Goth, Bada, 6. Gastka Tajia Gwalior, 7.Hurawali Road, Gwalior, 8.Near S.D.M Office Dabra, Gwalior

pH measures the activity of hydrogen ions (H^+) in the water. pH indicates the alkalinity and CO_2 concentrations of the water. Results show that pH of all the samples understudy varied from 6.98 to 8.03. Water from Morarnagar is slightly acidic in nature with pH value 6.98, while the water form Bal Bhavan is slightly basic with (8.03 pH).The pH values of all the water samples are within acceptable limits(pH 8.5) hence all the samples are permissible for drinking on the basis of pH[12,13].

Total dissolved solid (TDS) consists of inorganic and organic substances. Inorganic substances which include clay, silt, minerals, metals, etc. mainly in the form of carbonates, bicarbonates, chlorides, sulphates, phosphates, nitrates, calcium, magnesium and sodium can create taste, odor, hardness, corrosion and scaling problem. TDS of the different water samples ranged from 225.0 to 402.0 mg/L. All samples are in the permissible limit[12,14].

Electrical conductivity is directly linked to the concentration of the ionic impurities in the water. Conductivity measurements are influenced by pH levels and the temperature. Conductance of all the samples was ranged between 248µs/cm to 486µs/cm.

Hardness of water is caused by the presence of multivalent metallic cations and is largely due to calcium and magnesium ions. The low and high value of hardness has advantages and disadvantage. Hardness of all the water samples is found in the range of 170.94mg/L to 340.06mg/L. Hence all the samples fall in the category of hard and very hard[12].

Calcium is a major constituent of various types of rock. It is one of the most common constituent presents in natural water ranging from zero to several hundred milligrams per liter. Calcium ranged from 122.84mg/L to286.04 mg/L. It shows all the samples have high concentration of calcium. Excessive calcium may contribute to many health problems.

Magnesium is often associated with calcium in all kinds of water but its concentration remains generally lower than the calcium. Magnesium content in the samples under study ranged from 48.10mg/L to 119.85 mg/L.

Alkalinity is the content level of carbonate (CO_3^{2-}), bicarbonate (HCO_3^-) and hydroxide (OH^-) in water. Alkalinity is the main control factor for the aggressiveness of the water. Alkalinity of the samples varies from 150 mg/L to 390 mg/L. Alkalinity of sample is in permissible range [12].

Chloride is present in all natural water mostly at low concentrations. It is highly soluble in water. There is no known evidence that chlorides constitute any human health hazard. Chlorides are generally limited to 250mg/L to1000mg/L. Chloride ion concentration of all the samples varied from 47.02 to 90.10 mg/L and falls in permissible limits.

Iron is common constituent in ground water. It is present in water either as soluble ferrous iron or insoluble ferric iron. Taste of iron is not usually noticeable at iron concentrations below 0.3mg/L. Although iron has got little concern as a health hazard but is still considered as a nuisance in excessive quantities. Long time consumption of drinking water with a high concentration of iron can lead to liver diseases (Hemosiderosis). High concentration of iron in water is not suitable for processing of food, beverages, ice, dyeing, bleaching and many other items. The permissible iron concentration in ground water is less than 1.0mg/L as BIS standard. Total iron content in the samples lie between 0.1mg/L to 1mg/L, hence fall in permissible range.

Microbial Analysis: The microbial analysis is showed in table 2.

Table-2
Bacteriological analysis of water

Sample number	Cfu/ml	MPN index/100ml	Bacteria present
1.	48	20	Negative
2.	28	09	Negative
3.	$1.19 X10^2$	130	E.coli.
4.	54	11	E.coli, Enterobacter sp.
5.	09	07	Negative
6.	11	13	Negative
7.	36	09	Negative
8.	19 coli forms	Nil	Negative

The result of the microbial analysis of the water samples are shown in table 2, the presumptive coli form count or MPN index/100ml of the water samples ranged from Nil to 130/100ml, it indicates that sample no. 3 had the highest count of 130/100ml followed by sample no 1 (20/100ml). The total plate count was also highest in sample no 3 ($1.19X10^2$cfu/ml).The bacteria isolated on different selective media identified by biochemical tests were; *Escharichia coli, Enterobacter species*. These water samples were contaminated; this may be due to the illegal dumping of domestic waste.

Conclusion

The observation of study suggest that underground water which is recharged through water harvesting system indifferent region of Gwalior is suitable for drinking except sample no. 3 and 4 in which; *Escharichia coli, Enterobacter species*were identified. Water from these sources cannot be used for drinking purpose without pre-treatment.

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