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Research article

Study of Physico-chemical parameters of drinking and waste waters in Central Mountains in WadiMaytum, Ieb District , Yemen

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Abstract:

In the present study an attempt has been made to know the concentration of different physico-chemical and microbiological parameters in drinking/waste water samples collected from various wells of WadiMaytum, Ieb District, Yemen. Temperature, pH , EC, TDS, Total hardness, Turbidity, alkalinity, BOD,COD,Total coliforms, Faecal streptococci, sodium, magnesium, iron, calcium, lead, chromium, cadmium, copper, manganese, nickel, chloride, sulphate,nitrite, nitrate, ammonia and bicarbonate were assessed . The concentration levels of different parameters in the study samples are summarized , discussed and compared with drinking/waste water quality standards given by the WHO (1994;2006) APHA (2005)and SLS(1983) Standards. In our study, it was found that EC, TDS, TH, Alkalinity, COD, sodium, magnesium (except in closed well) , calcium and lead values were above permissible limit for drinking water whereas pH, turbidity, chlorine, sulphate, nitrates , nitrites, ammonia , iron, manganese, nickel (except in B and C wells), chromium, cadmium and copper values were within the permissible limit.

Keywords: Drinking /waste waters, physic-chemical parameters, microbiological parameters, WadiMaytum, Ieb District, Yemen.

Introduction:

Water is one of the prime necessities of life. Ground water is a precious natural water resource considered as a readily available and safe source of water. Water contamination due to pathogenic agents, heavy metals, and chemicals, and thereby product as a consequence of agricultural activities leaching from soil, rocks and atmospheric deposition and other human activities has become a hazard to human health in several regions of world. Many works have been done on the chemical analysis and environmental contaminants and their impact on some ground water quality in Taiz city, Yemen (AL-

Shargabi and Ghanem, 2015), in Iran (Zazouli et al., 2013), in Benin Republic (Kinsiclouunon et al., 2013).

Present study was carried out to assess the impact of existing waste or sewage water treatment station near wells used for drinking water in study area. In order to achieve this, open wells, closed wells, wells at distance after station and wells at distance before station, input (influent) and output (effluent) of sewage water wells of the station , water samples were analyzed. Parameters analyzed are temperature, pH , EC, TDS, Total hardness, Turbidity, alkalinity, BOD,COD,Total coliforms, Faecal streptococci, sodium, magnesium, iron, calcium, lead, chromium, cadmium, copper, manganese, nickel, chloride, sulphate,nitrite, nitrate, ammonia and bicarbonate.

Materials and methods:

Description of study area:

The study was conducted at the Central MountainsofWadiMaytum , Ieb District , Yemen , Feb 2015 to Feb 2016. It is located around 13 57 N and 44 11E.

Sampling:

The water samples were collected in well cleaned autoclaved bottles. The bottles prior to take water sample were rinsed several times with sample water. Electrical conductivity (EC), Total Dissolved Solids (TDS) and pH were measured immediately after collection and then ,the samples were immediately transferred to the laboratory and stored at temperature below 4 C for the analysis of the other parameters.

Bacteriological Examinations:

Poured Plate Method was used for enumeration of total bacterial counts using Plate Count Agar (PCA) medium. The numbers of organisms developed into colonies and were recorded as Colony Forming Unit (CFU) per ml.

Bacterial Indicators:

Total coliforms and Faecal streptococci were determined (APHA,2005). The Membrane Filter (MF) Technique was used to determine bacterial indicators in 100 ml sample. The Total Bacterial Counts were counted by using Pour Plate Method as CFU per 100 ml.

Analytical methods:

Water quality parameters such as pH , EC and TDS were measured at the site using digital pH/EC/TDS Meter (Model HI 98130). Spectrophotometer (HACH 2010) was used to measure COD , Nitrate and phosphate . Winkler s method was adopted to estimate BOD. Heavy metals and Total hardness were analyzed using atomic absorption spectrophotometer (AAS) and Versenate method respectively.

The coliform analysis was done immediately after collection of samples by a statistical estimation called Most Probable Number Method (MPN) using Mac Conkey broth (Collins et al., 1976).

Results and Discussion:

The physico-chemical and microbiological characteristics of drinking water samples taken from wells A- D and also from outlet (treated) and inlet (untreated) water samples were assessed.

Coliform populations:

The number of total coliforms in the samples varied from 231.5±229.5 to 2400±0.00 per 100 ml. High coliform populations in all the water samples are an indication of poor quality of water.

Physicochemical analysis:

Temperature: In the present study , temperature varied from 21.5 ±0.65 in open well (well A) to 22.75 0±0.25 C in well at distance after station (well C).

pH:pH values in the present study showed neutrality (around 7.0) in all ground water samples wells A-D) , which complies with the permissible limits (6.5 – 8.5).

Electric conductivity (EC): The conductivity of all groundwater samples in the present study, ranged between 942.4±59.91 and 1489.25±133.98 uS/cm. The minimum value was observed at well B , while maximum value was observed at well A. The highest desirable level of EC at 25 C is 750 uS/cm (SLS,1983).

Total Dissolved Solids (TDS):TDS were high in the range of 596.2±38.84 to 990.375±92.34 ppm. The highest value of TDS were recorded at open and after station wells. These values exceeded the maximum allowable limit of 250 ppm for drinking water (WHO, 1997). The presence of high amount of inorganic materials might have attributed for highest values of TDS in the well water samples.

Total Hardness (TH): Total Hardness (TH) was found in range of 442.55±14.8 to 699.23±99.00 ppm , all the analyzed water samples were not fall within the maximum allowable limit of 400 ppm. Table 2 shows that TH is high in open and after station wells. This may be due to weathering of more basic rocks in the vicinity and runoff from the adjacent site.

Alkalinity: The alkalinity values were ranged from 361.2±12.32 (in well B) to 579.65±79.48 (in well A).

Turbidity: The turbidity values were ranged from 0.2175±0.11 (in well C) to 1.45±0.55 (in well B) Nephelometric Turbidity Unit (NTU) at all ground water samples. All water samples showed turbidity values lower than the permissible limits (more than 1 NTU) except well B.

Chloride: The minimum value 109.375±7.417 chloride was observed at well B, whereas the maximum value 212.075±39.94 was noted at well A. All values within the permissible limits at (less than 250 ppm).

Sulphate: Thesulphate values were found to be less in well B. All sulphate concentrations in the ground water samples were within the permissible limits (less than 250 ppm).

Nitrite: It was observed that the concentration of nitrite were ranged from 0.0938±0.05in well D to 0.199±0.11 ppm in well B (Table 2) ,

that were not exceed the WHO maximum allowablelimit of 50 ppm.

Nitrate: The maximum value of nitrate at 21.15± 8.15 ppm was recorded at well D whereas the minimum 6.125± 0.79 ppm was noted at well A. The nitrate contents of the samples were within the permissible limits (less than 50ppm).

Ammonia: The ammonia content of samples (A-D) ranged from 0.0845 ±0.05 to 0.2378±0.08 ppm. The minimum value was found to be o.0845±0.05 ppm at well A , whereas the maximum value 0.2378±0.08 ppm was observed at well C. Results of ammonia in the examined ground water samples (A-D) were lower than the permissible limits (less than 0.5 ppm).

Bicarbonate: The maximum value of bicarbonate at 667.225±116.62 ppm was recorded at well Cwhereas the minimum was noted at wellB.

Biochemical Oxygen Demand (BOD): Based on this study, BOD at all wells ranges from 14.9±12.70 to 73.2±16.39 ppm. High BOD values (5-10 ppm) indicate the presence of water with high amount of organic contaminants or water of low quality.

Chemical Oxygen Demand (COD): The level of COD in samples varied from 28.775±24.15 to 467.925±121.96 ppm and exceeded the SLS maximum permissible level of 10 ppm. Water in this area is contaminated with organic pollutants rendering it not suitable for drinking purposes.

Sodium :. All drinking water samples have sodium higher than the permissible limits (WHO, 2006) except water sample from well B.

Magnesium :. All drinking water samples have magnesium within the permissible limits(WHO,2006).

Iron : All drinking water samples have iron within the permissible limits (WHO,2006) except water samples from A and D wells.

Calcium : The maximum acceptable limit for calcium per WHO is 75 ppm. However, the observed concentration levels of Ca are observed exceeded the permissible limits.

Lead : Detectable lead concentration in drinking water samples was found to be in the range of 0.11673 – 0.5375 ppm. All drinking samples exceeded the WHO safe limit of 10 ug/L.

Chromium: The maximum acceptable limit for chromium per WHO is 0.05 ppm. However, the observed concentration levels of Cr are observed exceeded the permissible limits.

Cadmium: Based on the safe limit set by WHO for cadmium at 0.005 ppm , all of the drinking water samples exceeded the specifications. Cd concentration for all samples was found to be higher than detection limit.

Copper: Copper concentration vary from 0.1170±.03 to 0.26±0.06 ppm in the water samples. Acceptable limits are given for copper in WHO guidelines.

Manganese: Detectable manganese concentration in drinking water was

found to be in the range of 0.03750±.02 to 0.05180±.003 ppm. All samples are within the permissible limits.

Nickel : Nickel concentration levels in drinking water samples was ranged from 0.02075 ± 0.01 to 0.04475 ± 0.003 ppm. The maximum acceptable limit for Nickel as per WHO is 0.07 ppm. The observed concentration levels of Ni are within the permissible limits.

Waste (sewage) water may affect the aquatic (wet) environment in three main ways; through oxygen depletion , by causing disease and by nutrient enrichment when sewage decomposes it uses up oxygen from the surrounding water and if the discharged concentration is too high, the amount of oxygen available for aquatic life will be insufficient and leading to morbidity. Sewage contains pathogenic bacteria and viruses which pose a risk to public health. Sewage discharges contain nutrients which will increase algae and plant growth under certain conditions. These algae may produce toxins and can cause oxygen depletion when decomposition takes place.

Generally, according to treated wastewater criteria for reuse (APHA, 2005;WHO, 2006) temperature, pH, TDS, turbidity, chloride, nitrite, nitrate, ammonia , bicarbonate, copper, manganese and nickel were within the permission limits.

Conclusion:

The drinking water samples which was taken from the opened well, closed well, wells at distance after station and wells at distance before station, input (influent) and output (effluent) of sewage water wells of the station were analyzed. The drinking water quality parameters such as pH, turbidity, chloride, sulphate, nitrite, nitrate, ammonia, iron (except D and A wells), lead,chromium, cadmium , manganese and nickel (except B and C wells) lies within the maximum permissible limit prescribed by WHO (1993,2006), APHA (2005) and SLS (1983). The EC, TDS,TH,Alkalinity, COD, sodium, magnesium (except closed well) and calcium of some samples were reported higher than the permissible level. It was found that some of the water samples are non-potable for human being due to high concentration of total dissolved solids and total hardness.

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Table 1. Average of Bacterial indicators (CFU/100 ml)

Well	**Bacterial Parameters**	
	Total Coliforms	**Faecal Streptococci**
Opened (A)	2400±0.00	18.00±0.00
Closed (B)	231.5±229.5	5.25±4.25
After station (C)	605.25±598.26	6.74±4.01
Before station (D)	603.25±598.92	3.00±2.00
wastewater (Input)	2400±0.00	18.00±0.00
Wastewater (Output)	2400±0.00	18.00±0.00
Maximum Allowable Concentration	400 MPN/100ml	20 MPN/100ml

Table 2. Physico-chemical parameters of ground water samples wells (A-D)

Parameters	**Well A (Opened)**	**Well B (Closed)**	**Well C** well at distance after station	**Well D** well at distance before station	**Maximum Allowable concentrations**
Temperature (C)	21.5±0.65	22.5±0.29	22.75±0.25	22.00±0.41	NG
pH	7.325±0.025	7.275±0.05	7.20±0.04	7.225±0.05	6.5-8.5
EC uS/cm	1489.25±133.98	942.4±59.91	1200.8±184.99	1024.8±143.47	750
TDS	990.37592.34	596.2±38.84	795.8±115.26	662.225±94.62	250
TH	699.225±99.00	442.55±14.800	509.5±36.95	478.325±71.80	400
Alkalinity	579.65±79.48	361.2±12.32	426.325±33.36	396.325±63.79	200
Turbidity (NTU)	0.72±0.42	1.45±0.55	0.2175±0.11	0.295±0.118	1.00
Chloride	212.075±39.94	109.375±7.41	132.65±23.88	118.875±14.73	250
Sulphate	112.325±10.32	56.65±4.37	80.075±20.80	87.975±18.35	250
Nitrite	0.145±0.05	0.199±0.11	0.15±0.0.07	0.0938±0.05	50
Nitrate	6.125±0.79	12.725±2.96	14.675±1.80	21.15±8.15	50
Ammonia	0.142±0.04	0.144±0.11	0.2378±0.08	0.0845±0.05	0.5
Bicarbonate	589.3±55.98	397.45±8.11	667.225±116.62	477.225±79.54	NG
BOD	73.2±16.39	15.65±14.99	21.0375±19.26	14.9±12.70	5.00
COD	467.925±121.96	28.775±24.15	37.725±34.60	30.2125±21.24	10
Sodium	42.5±4.43	30.225±3.37	40.225±9.15	39.65±7.17	200
Magnesium	34.95±12.99	21.4±1.52	35.625±13.52	32.55±5.20	30
Iron	0.668±0.44	0.365±0.267	0.471±0.267	0.645±0.26	0.5
Calcium	205.225±24.62	136.55±8.61	203.95±44.964	151.075±30.50	75
Lead	0.11673±0.065	1.9425±0.39	0.4785±0.096	0.5375±0.101	0.1
Chromium	0.4275±0.20	0.4285±0.1416	1.810±0.272	1.525±0.397	0.05
Cadmium	0.143±0.08	0.275±0.185	0.663±0.171	0.133±0.076	0.005
Copper	0.26±0.06	0.117±0.03	0.26±0.06	0.1185±0.03	2.00

Manganese	0.0375±0.02	0.0425±0.011	0.0518±0.003	0.041±0.012	0.5
Nickel	0.02075±0.01	0.030±0.008	0.04475±0.003	0.025±0.008	0.07

Standards for Drinking water: WHO (1994); WHO (2006); APHA (2005); SLS (1983). NG = NO Guide.

Table 3. Analysis of Physico-chemical parameters of wastewater samples - Input (untreated) and output (treated)

Parameters	**Input (untreated or influent)**	**Output (treated or effluent)**	**Maximum Allowable concentrations**	**Removal Efficiency % (RE)**
Temperature (C)	19.5±4.5	19.5±4.5	20 – 35 C	0.00
pH	7.25±0.05	7.15±0.05	6.5-8.5	1.38
EC uS/cm	3235.95±28.35	2642.5±25.5	NG	18.34
TDS	2145.65±23.35	1614.15±19.85	1500	24.77
TH	1415.95±10.65	945.8±85.2	NG	33.02
Alkalinity	1172.95±31.35	1118.65±15.65		4.63
Turbidity (NTU)	72.65±14.05	37.3±8.3	5.00 NTU	48.66
Chloride	686.3±54.3	290.45±78.15	200	57.68
Sulphate	269.6±31.00	126.6±23.00	NG	53.04
Nitrite	2.75±0.55	2.35±0.05	50	14.55
Nitrate	192.8±4.2	113.5±10.5	50	41.13
Ammonia	284.3±21.7	228.45±16.15	15	19.64
Bicarbonate	730.5±45.5	514.3±44.00	400	29.60
BOD	2173.15±166.85	114.367±3.97	20 mg/L	94.74
COD	2546.167±51.5	849.08±711.25	100 mg/L	66.65
Sodium	86.95±95	41.65±5.35	200	52.10
Magnesium	55.65±7.65	30.00±10.00	150	46.09
Iron	4.965±0.655	1.965±0.475	5.0	60.42
Calcium	219.3±49.7	150.3±26.3	0.01	31.46
Lead	1.15±0.13	1.14±0.13	0.1	0.87
Chromium	2.98±0.69	1.995±0.505	1.0	33.05
Cadmium	1.105±0.595	0.61±0.59	0.1	44.80
Copper	1.18±0.36	0.695±0.365	2.0	41.10
Manganese	0.465±0.035	0.18±0.15	5.0	61.29
Nickel	0.215±0.125	0.155±0.135	0.5	27.91

Treated wastewater criteria for re-use : WHO (2006); APHA (2005).

NG = NO Guide