

Assessment of Open well Water Quality around Puttalam District, Sri Lanka

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ABSTRACT

This study focused upon the determination of physicochemical parameters, in drinking water samples of different areas in Puttalam district, Sri Lanka. The purpose was to evaluate the quality of water from these bases. Twenty well water samples were collected from different areas of Puttalam district and analyzed for physicochemical parameters including BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), Total Hardness, Chloride content, TDS (Total Dissolved Solids) and pH. Some Anions (NO_3^- and Cl^-) were analyzed for the collected samples. All twenty samples were analyzed separately and were compared with the water quality standard prescribed by the World Health Organization (WHO). It was found that the mean pH values were generally almost the same for the investigated drinking water samples ranged from 6.20 ± 0.0707 - 7.26 ± 0.007 . The well water samples were shown wide variations in other physicochemical parameters. The data showed variations of the investigated parameters in samples are BOD: 1.28 ± 0.0070 - 5.08 ± 0.0141 ppm, COD: 2.88 ± 0.0212 - 24.96 ± 0.070 ppm, Total hardness: 20 ± 1.41241 - 800 ± 1.414 ppm, Chloride content: 35.45 ± 0.9404 - 602.65 ± 0.169 ppm, nitrate, 0.0010 ± 0.03 - 78.4965 ± 0.67 ppm, TDS: 100 ± 2.8284 - 2000 ± 2.828 mg/L. The concentrations of most of the investigated parameters in the selected drinking water samples from different areas in Puttalam district were not within the permissible limits of the World Health Organization drinking water quality guidelines.

Key words: *Physicochemical, Total hardness, Biological oxygen demand, Total dissolved solid.*

1. INTRODUCTION

Water is an important requirement of human life and activities related with industry, agriculture, and others, and it considers one of the most delicate parts of the environment. In the last few decades, the enhanced pace of industrial development and progressive growth of population caused in tremendous increase in the demand of fresh water. The quality of surface and groundwater is recognized in terms of its physical, chemical, and biological parameters.

Assessment of well water (drinking water) quality around Puttalam district was the main purpose of this research. In Puttalam district some people are using municipal water supplies and some are using their private well water supplies which are not monitored by government or municipal agencies. This means the well owner must take concern for monitoring well water quality. For the last few decades most of well water around Puttalam district subjected to polluted by a number of sources. These are agricultural activities, human settlement, deforestation, Industrial waste especially because of shrimp farming practices, salt production processes, Coir fiber production processes and cement industry etc.

Ground water quality is a great importance due to its effect on human well-being and aquatic ecosystem. So I selected twenty wells and collected twenty water samples from these different areas of Puttalam district and also different parameters were analyzed during the study. All the twenty samples were analyzed separately to get the results and were compared with water quality standard prescribed by WHO (World Health Organization) whether they are suitable or not for drinking purposes.

Safe drinking water is a basic requirement for good health, and it is also a basic right of humans. Fresh water is now a limiting resource in many parts of the world. In the next century, it will become even more limiting due to enlarged population, urbanization, and climate change [1]. Drinking water quality is a comparative term that relates the composition of water with

effects of natural processes and human activities. Deterioration of drinking water quality rises from introduction of chemical compounds into the water supply system through leaks and cross connection [2]. The quality of water is affected by an rise in anthropogenic activities and any pollution either physical or chemical causes variations to the quality of the receiving water body [3]. Chemical pollutants occur in drinking water throughout the world which could probably threaten human health. In addition, most sources are found near gullies where open field defecation is common and flood-washed wastes disturb the quality of water [4]. The World Health Organization estimated that up to 80 % of all sicknesses and diseases in the world are produced by inadequate sanitation, polluted water or unavailability of water [5]. A review of 28 studies carried out by the World Bank gives the evidence that frequency of certain water borne, water washed, and water based and water sanitation associated diseases are correlated to the quality and quantity of water and sanitation available to users [6].

BOD is a chemical process for determining the amount of dissolved oxygen needed by aerobic organisms in a water body to break the organic materials present in the given water sample at definite temperature over a specific period of time. BOD is the primary test to give an idea of the biodegradability of any sample and strength of the waste. Hence the amount of contamination can be easily measured by it. This is significant parameter to assess the pollution of surface water and ground water where contamination occurred due to disposal of domestic and industrial effluents. Drinking water usually has a BOD of less than 1 mg/L. But when BOD value ranges 5 mg/L the water is unsure in purity. Biochemical Oxygen Demand (BOD) mentions to the amount of oxygen that would be consumed if all the organics in one liter of water were oxidized by bacteria and protozoa [7].

The determination of Chemical Oxygen Demand (COD) test measures the Oxygen required oxidize organic matter in water and waste water samples by the action of strong oxidizing agents under acid conditions. It is said in milligram per liter (mg/L), which shows the mass of Oxygen consumed per liter of solution. This analysis is of interest since carbon compounds function a food supply for microorganisms.

Water hardness is an expression for the Calcium and Magnesium cations in a water sample. Calcium is usually found in highest concentration in natural water. The presence of Calcium in water results from deposits of limestone, gypsum etc. Water hardness is the earliest measure of the capacity of water to react with soap, hard water requiring considerably more soap to produce a lather. Hard water frequently produces a perceptible deposit of precipitate in containers, including “bathtub ring”. It is not caused by one substance but by a range of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations, although other cations (e.g. Aluminium, Barium, Iron, Manganese, Sr and Zinc) also contribute. Hardness is most typically expressed as milligrams of Calcium carbonate equivalent per litre. Water containing Calcium carbonate at concentrations below 60 mg/L is generally considered as soft; 60–120 mg/L, moderately hard; 120–180 mg/L, hard; and more than 180 mg/L, very hard [8].

Although hardness is caused by cations, it should even be mentioned in terms of carbonate (temporary) and non-carbonate (permanent) hardness. Small water provides using groundwater frequently encounter significant levels of hardness, but some larger surface water supplies also have the same issue. Calcium concentrations up to and beyond 100 mg/L are common in natural sources of water, principally groundwater. Magnesium is present in natural groundwater typically at lower concentrations (from negligible to about 50 mg/L and rarely above 100 mg/L), so calcium-based hardness typically predominates [9].

Inadequate intakes of calcium have been related with increased threats of osteoporosis, nephrolithiasis (kidney stones), colorectal cancer, hypertension and stroke, coronary artery disease, insulin resistance and obesity. Most of these complaints have treatments, but not cures. Due to a lack of compelling evidence for the role of calcium as an influential element in relation to these diseases, assessments of calcium requirement have been made on the base of bone health outcomes, with the goal of optimizing bone mineral density.

The high concentration of Chloride ions generally causes in an unpleasant salty taste of water and it also aides the corrosion of plumbing system. Very high Chloride content of water may also create laxative effect. An increase in the normal Chloride content of water may specify possible pollution from human sewage, animal compost or industrial waste. Chloride linked with Sodium (Sodium Chloride) exerts salty taste when its concentration is more than 250 mg/L. These influence a salty taste to water. Chlorides are generally restricted to 250 mg/L in water provides meant for public water supply. Chloride determination is used to switch pumping of ground water from places where intrusion of seawater is a problem. Chloride determination is used to determine the type of desalting equipment to be used. Chloride determinations in natural waters are useful in selection of water provisions for human use. Ground water forms frequently have high concentration of chlorides as compare to surface water. It has significant importance for metabolism activity in human body and other key physiological processes. High chloride concentration harms metallic pipes and structure, similarly as harms growing plants. According to WHO standards, concentration of chloride shouldn't exceed 250 mg/L.

Determination of pH is one of the main objectives in biological management of water. In anaerobic treatment, if the pH goes below 5 due to excess gathering of acids, the process is severely affected shifting of pH beyond 5 to 10 upsets the treatment of the waste water. High pH induces the development of tetra helomethanes which are producing cancer in human being. Drinking water with a pH between 6.5 and 8.5 is commonly considered satisfactory. The pH value of drinking water is a vital index of acidity,

alkalinity and subsequent value of the acidic basic interaction of a number of its mineral and organic components. The pH below 6.5 starts corrosion in pipes. Toxic metals present in water causes an increase in the pH value of water.

Water containing TDS concentrations below 1000 mg/L is usually satisfactory to consumers, although acceptability may vary according to situations. However, the presence of high levels of TDS in water may be objectionable to consumers due to the resulting taste and to unnecessary scaling in water pipes, heaters, boilers, and household uses. Water with very low concentrations of TDS may also be undesirable to consumers because of its flat, insipid taste; it is also often corrosive to water-supply systems.

In areas where the TDS content of the water supply is very high, the individual constituents should be recognized and the local public health authorities checked. This is the important limit for the use of water. The water with high TDS value specifies that water is highly mineralized. Needed limit for TDS is 500 mg/L and maximum limit is 1000 mg/L which recommended for drinking purposes.

Nitrate in the environment creates mostly from organic and inorganic foundations such as waste discharges, animal slurries and artificial fertilizer. High levels of nitrate in drinking water may tempt “blue baby” syndrome (methaemoglobinemia) in infants. The nitrate converts to nitrite which reacts with blood hemoglobin thus reducing the obtainability of the blood to hold oxygen. The WHO allows maximum allowable limit of nitrate 5 mg/L in drinking water.

2. MATERIAL AND METHODS

2.1 Study Area

In the present study Well water samples were randomly collected taken from twenty difference areas located in and around Puttalam [district](#) were collected in brown glass bottles with necessary precautions. In this study the selection criteria of the sampling locations were based on the characteristic of water conditions, land use, anthropogenic activities (Cement industry, salt industry etc.) around this area.



Figure 1: Sampling area

Table 1. Sampling area and water samples

Area	Water Sample
Pathtayama	A
Welasiya	B
Pallama	C
Adigama	D
Bangadeniya	E
Thoduwawa	F
Palaviya	G
Kalpitiya	H
Palasole	I
Mahakubukkadawala	J
Chilaw	K
Puttalam	L
Madampe	M
Anamaduwa	N
Wennappuwa	O
Madurankuli	P
Ambalaweliya	Q
Marawila	R
Mundel	S
Wanathawilluwa	T

2.2 Sampling Procedure

The 250 ml plastic bottles were washed well and rinsed with industrial HCl (2%, 2ml). The bottles were rinsed again with sampled water and the water samples were collected securely and sealed with proper labeling. Aeration during sample was avoided as far as possible. The water samples were transported to the laboratory and are preserved for physical and chemical analysis. Samples were collected from well in the distance of about 100 meter from one sample to another [10].

2.3 BOD value of water

Dissolved Oxygen was determined using the method of Winkler method [11].

The Biochemical Oxygen Demand (BOD) of contaminated water is the amount of oxygen required for the biological decomposition of dissolved organic matter.

2.4 COD value of water

The quantity of COD determines the quantities of organic matter found in water. This makes COD useful as an indicator of organic pollution in surface water. 0.125 M solution of oxidizing agent is used in the determination. Normality double the strength is used. Excess amount of oxidizing agent is added, the excess is determined by another reducing agent such as ferrous ammonium sulphate. Ferrous indicator is used to titrate the excess dichromate against ferrous ammonium sulphate. To get the correct value of COD, blanks are treated and titrated [10].

2.5 Total hardness of water

Total hardness of water was determined by using titration method. Hardness buffer solution (1mL) was added to 50 ml of water sample (50 mL) followed by the addition of 1 to 2 drops of indicator. Then, this solution is titrated against versenate solution (EDTA solution) from burette, end point reddish to blue colour.

2.6 pH value of water

Electric pH meter (was first calibrated with buffer solution of buffer 4.0, 7.0 and 9.2) was prepared. Then the pH meter (HACH, HQ40d) was calibrated to 9.2 using buffer and by adjusting the calibrating knob. (Likewise 7 & 4) then cleaned with distilled water. The electrode of pH meter was dipped in each sample one by one. The values were noted [12].

2.8 TDS value of water

Water sample (20 ml) was taken in a pre-weighted china dish. The samples were dried in an oven for 2 hour. Then it was cooled in desiccators and weighed [12].

2.9 Chloride Value of water

Potassium chromate indicator was prepared as (1 g) of potassium chromate was dissolved in 20 ml of distilled water. Silver nitrate was prepared as (4.25 g) of silver nitrate was dissolved in 250 ml of distilled water. 20 ml of filtrate sample was taken in 100 ml flask. A few drops of potassium chromate indicator were added. Titration was performed with silver nitrate till a brick red color appeared. A reagent blank was established by using the same method [13].

2.10 Nitrate value of water

Nitrate content of water samples under investigation was determined using UV-visible, spectroscopic method. Nitrate calibration standards (using volumetric method) were prepared in the range of 2 ppm, 4 ppm, 6 ppm, 8 ppm and 10 ppm by serially diluting appropriate amount of 100 mg/L stock solution. Each standard were treated with HCl (1M, 1 ml) and each samples were transferred in to a square UV- cuvette and the absorbance were measured at two different wave length of 220 nm and 275 nm. Then water samples were taken and filtered to remove particles. Then each sample (25.0 ml) was pipetted out into a beaker and HCl (1M, 1 ml) were added into each samples. Then the absorbance was measured in two different wave length (220 nm, 275 nm) for blank (standard) solution. Then the absorbance of each sample was measured at two different wavelengths. Then standard curve was constructed by plotting the absorbance due to nitrate against the nitrate concentration of standards. Then using Beer's law, Nitrate concentration of samples was determined from standard curve.

3. RESULTS AND DISCUSSION

Table 3.1. BOD, COD, Total hardness, Chloride Content ,Nitrate value, TDS value and pH value of water samples under investigation

Water sample	BOD \pm SD (ppm)	COD \pm SD (ppm)	Total hardness \pm SD (ppm)	Chloride content \pm SD (ppm)	Nitrate \pm SD (ppm)	TDS \pm SD (mg/L)	P ^H \pm SD
A	2.60 \pm 0.1414	5.76 \pm 0.014	100 \pm 0.707	124.075 \pm 0.697	4.0701 \pm 0.01	450 \pm 17.677	6.97 \pm 0.0070
B	2.60 \pm 0.0707	2.88 \pm 0.0212	560 \pm 1.4142	381.0875 \pm 1.04	0.0010 \pm 0.03	1900 \pm 35.35	6.67 \pm 0.0141
C	5.04 \pm 0.0212	15.36 \pm 0.007	360 \pm 3.5355	354.50 \pm 0.0318	1.7293 \pm 0.03	1350 \pm 7.071	6.88 \pm 0.0212
D	4.16 \pm 0.0141	13.44 \pm 0.007	120 \pm 7.071	177.25 \pm 4.454	2.6210 \pm 0.00	700 \pm 35.355	6.83 \pm 0.0070
E	3.84 \pm 0.0070	24.96 \pm 0.070	800 \pm 1.414	602.65 \pm 0.0707	0.8694 \pm 0.05	2000 \pm 2.828	6.34 \pm 0.0141
F	2.64 \pm 0.0212	9.60 \pm 0.070	140 \pm 1.414	53.175 \pm 0.7629	43.5605 \pm 0.6	1100 \pm 8.485	6.97 \pm 0.0141
G	1.28 \pm 0.0070	13.44 \pm 0.007	240 \pm 1.414	230.425 \pm 1.499	0.8216 \pm 0.024	1750 \pm 2.121	6.72 \pm 0.0141
H	2.68 \pm 0.0070	3.84 \pm 0.021	80 \pm 1.414	35.45 \pm 0.7566	15.7739 \pm 0.08	500 \pm 7.0710	6.99 \pm 0.0070
I	1.60 \pm 0.0700	3.84 \pm 0.014	220 \pm 3.5355	177.25 \pm 1.195	15.6943 \pm 0.04	5400 \pm 3.535	6.70 \pm 0.1414
J	3.08 \pm 0.0212	5.76 \pm 0.0141	220 \pm 3.5355	88.625 \pm 0.7276	36.6656 \pm 0.14	250 \pm 17.677	6.82 \pm 0.0070
K	5.08 \pm 0.0070	11.52 \pm 0.007	50 \pm 3.5355	88.625 \pm 2.239	0.8535 \pm 0.02	1150 \pm 5.656	6.20 \pm 0.0707
L	3.32 \pm 0.0140	13.44 \pm 0.014	720 \pm 2.121	602.65 \pm 0.169	4.3089 \pm 0.01	4100 \pm 4.949	6.29 \pm 0.0141

M	4.24 ± 0.0070	13.44 ± 0.014	40 ± 0.7071	35.45 ± 0.9404	4.5796±0.08	150±7.071	6.99±0.014
N	4.76 ± 0.0141	9.60 ± 0.0707	50 ± 1.414	53.175 ±0.4306	1.8694±0.01	160±3.5355	6.89±.02828
O	3.52 ± 0.0070	9.60 ± 0.2828	160 ± 1.141	17.725 ±0.0707	78.4965±0.67	100±2.8284	6.65±0.0070
P	4.72 ± 0.0212	13.44 ± 0.021	180 ± 2.828	70.90 ±0.4384	6.6815±0.02	650±0.7071	6.63±0.007
Q	4.76 ± 0.0353	11.52 ± 0.007	200 ± 1.4142	292.4625 ±1.26	0.4395±0.07	1200±2.121	6.64±0.0212
R	5.08 ± 0.0141	11.52 ± 0.032	30 ± 1.4142	17.725 ±0.5628	6.3471±0.03	100±2.8284	6.91±0.0282
S	4.40 ± 0.0707	5.76 ± 0.0014	20 ± 1.41241	35.55 ±0.707	0.3599±0.07	250±3.5355	7.26±0.007
T	2.56 ± 0.0141	3.84 ± 0.035	40 ± 1.141	53.175 ±0.3040	0.9172±0.04	150±1.414	6.68±0.007

Table 3.2. Different analytical water quality parameters with their guideline values as per WHO standard

Parameters	WHO standards for drinking purpose
BOD value (ppm)	1-2 ppm
Total hardness (ppm)	500 mg/L
Chloride content (ppm)	250 mg/L ≥
pH value	6.5 – 8.5
TDS value	500 mg/L
Nitrate value	5 ppm

3.1 BOD of water

BOD (Biological Oxygen Demand) content of water samples in studied area were between (1.28 – 5.08) ppm. The lowest BOD value was recorded in ‘G’ (Palaviya) water sample and the highest BOD value was recorded in K and R (Chilaw and Marawila). So water samples of some studied area were not in permissible limit for drinking purposes. Because most of water samples exceed the 1- 2 ppm limit and water are not within recommended permissible limit for drinking purpose by WHO.

3.2 COD of water

Chemical Oxygen Demand (COD) content of water samples in studied area was between the ranged from 2.88 – 24.96 ppm. The lowest COD value was recorded in ‘B’ well water sampling area and the highest COD value recorded at ‘C’ sampling area. Most of water samples were not within recommended permissible limit for drinking purpose by WHO.

3.3 Total hardness of water

The Calcium hardness ranged of analyzed water samples between (20 – 800) mg/L. The maximum value was recorded in ‘E’ (Suhadagama) water sample and the minimum value was recorded in ‘S’ (Mundel) water sample. So that some of the water samples were pose water quality problems because the hardness concentration was not on the recommended limit of WHO. The tolerance range for Calcium hardness is 500 mg/L as prescribed by WHO.

3.4 Chloride content

In studied area the Chloride content of water samples were between 17.725 – 602.65 ppm. The lowest Chloride value was recorded in ‘O’ (Wennappuwa) water sample. The highest Chloride value was recorded in ‘E’ (Bangadeniya). The results of Chloride content in some of analyzed water samples (B,C,E,G,L) are not within the permissible limit when compared with the standard value of WHO. The permissible range for Chloride is ≤ 250 mg/L as prescribed by WHO.

3.5 TDS value

The concentration of TDS in present study was observed in the range of 100-5400 mg/L. The mean total dissolved solids concentration of well water samples in puttalam district was found to be 1192.5 mg/L, and it is not within the limit of WHO

standards. The lowest TDS value were obtained in water sample 'O' and R and the highest TDS value was obtained in water sample 'I' (Palasole). Desirable limit for TDS is 500 mg/L and maximum limit is 1000 mg/L which prescribed for drinking purpose by WHO.

3.6 Nitrate content in water

In the present study, the Nitrate content of water ranged from – 1.8694 ppm to 78.4965 ppm. Maximum value recorded at the station of 'O' and the minimum value recorded at the station 'N' The permissible value of Nitrate is 5 mg/L prescribed by WHO. So according to the results water of the sampling stations of F,H,I,J,O,R were not in permissible limit of Nitrate of , when compared with standard value of WHO.

4. CONCLUSION

During the analysis, it was found that most of well water samples of Puttalam were not in permissible limit of World Health Organization for drinking purposes. It was evident from the data that the values of most of the parameters were increasing towards non permissible limit as that of World Health Organization. It was found that the mean pH values were generally almost the same for the investigated drinking water samples ranged from 6.20 ± 0.0707 - 7.26 ± 0.007 . The well water samples were shown wide variations in other physicochemical parameters. The data showed variations of the investigated parameters in samples are BOD: 1.28 ± 0.0070 - 5.08 ± 0.0141 ppm, COD: 2.88 ± 0.0212 - 24.96 ± 0.070 ppm, Total hardness: 20 ± 1.41241 - 800 ± 1.414 ppm, Chloride content: 35.45 ± 0.9404 - 602.65 ± 0.169 ppm, nitrate, 0.0010 ± 0.03 - 78.4965 ± 0.67 ppm, TDS: 100 ± 2.8284 - 2000 ± 2.828 mg/L. The concentrations of most of the investigated parameters in the selected drinking water samples from different areas in Puttalam district were not within the permissible limits of the World Health Organization drinking water quality guidelines.

The results vary with different collecting locations because of different contaminations. The water under investigation could be good for agricultural purposes but can rarely be used for drinking purposes. The well water sample collected from Welasiya (B) Pallama (C), Bangadeniya (E), Palaviya (G), Puttalam (L), Wennappuwa (O), Madurankuliya (P) and Ambalaweliya (Q) areas were contaminated may be due to shrimp farming practices, agricultural activities (fertilizers), industrial waste and Domestic waste. The well water samples collected from Kalpitiya (H), Palasole (I), Mahakubukkadawala (J) Thoduwawa (F), Wennappuwa (O) were found contaminated may be due to agricultural activities (fertilizers). The well water samples collected from Puttalam (L), Madurankuliya (P), Palaviya (G), were contaminated may be due to salt production industry, cement production industry, and domestic waste.

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