Analysis and Treatment of Water Quality of Shallow Well from Semihtun Village in Amarapura Township

Soe Win[1], Khin Swe Oo[2], Aye Aye Mar[3], Aye Myo Han[4]

Abstract

According to the geographic nature of Myanmar, there are many resources of fresh water such as surface water (rivers, lakes and ponds) and ground water (tube well and shallow well). All of this water including ground water is not recommended as a potable water source for drinking purposes unless appropriate treatments such as coagulation, filtration, softening and adsorption for water quality. In this research, the ground water samples to be analyzed were collected from the shallow well in Semihtun Village near Yadanabon University from November, 2015 to October 2016. To evaluate the ground water quality, its physico-chemical characteristics such as pH, temperature, color, conductivity, turbidity, total alkalinity, total hardness, calcium hardness, total dissolved solids, dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD)and traces of constituents like arsenic, phosphate, cyanide, nitrite, nitrate, hydrogen sulphide, sulfate, fluoride, free chlorine, and total chlorine were determined monthly. In addition, its biological characteristics in terms of *Escherichia coli* count (*E.coli*), standard plate count and probable coliform count were also examined throughout the year. To reduce the contaminants, shallow well water was treated by coagulation, followed by filtering through the medium consisting of sand, gravels, cotton fiber and charcoal. After filtration, the water was aerated under sunlight for 24 hours and it was filtered again by charcoal. The characteristics of treated water sample was also evaluated to assess the effect of the water treatment methods. The values of most physico-chemical characteristics and some undesirable constituents of treated water were decreased significantly, although dissolved oxygen (DO) content was increased after treatments.

Keywords: Shallow Well, Water Quality, Physico-chemical Characteristics, Biological Characteristics

Introduction

Shallow wells are normally the means of accessing ground water of shallow depth (Shallow ground water table). In this water supply system, skilled people dig into the soft ground formations (sandy to clay) until they strike the water table. A shallow well is called "unprotected" when its top is not properly covered (because dirty blown by wind or carried by surface flowing water or even the pails from the ground it rests on can enter and pollute the well before going in the well). When fitted with a proper lid on top, it is called a protected well. In some cases, a hand-pump is also fitted to increase the protection.

Generally, groundwater quality varies from place to place, sometimes depending on seasonal changes, the types of soils, rocks and surfaces through which it moves. Naturally, occurring contaminants are present in the rocks and sediments. As groundwater flows through the sediments, metals such as iron and manganese are dissolved and may later be found in high concentrations in the water. In addition, human activities can alter the natural composition of groundwater through the disposal or dissemination of chemicals and microbial matter on the land surface and into soils, or through injection of wastes directly into groundwater. Industrial discharges, urban activities, agriculture, groundwater plumage and disposal of waste can affect groundwater quality. Pesticides and fertilizers applied to lawns and crops can accumulate and migrate to the water tables thus affecting both the physical, chemical and microbial quality of water.

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Water quality is the composition of water as affected by natural processes and human activities. Water quality is the constituents dissolved of contained within the water (http//www.ohiodnr.gov/soil and water/). Ground water quality comprises the physical, chemical, and biological qualities of ground water. Temperature, turbidity, color, taste, odor make up the list of physical water quality parameters. Most ground water is colorless, odorless, and without specific taste. It can typically be concerned with its chemical and biological qualities.

Naturally, ground water contains mineral ions. These ions slowly dissolve from soil particles, sediments, and rocks as the water travels along minerals surfaces in the pores or fractures of the unsaturated zone and the aquifer (http://www.ground-water.ucdavis.edu/files/ 136273.pdf).

Water treatment requires chemical, physical, and sometimes biological processes to remove contaminants. The most common processes used in potable water treatment are the chemical and physical processes. The chemical processes involved in potable water treatment include oxidation, coagulation, and disinfection. The physical processes include flocculation, sedimentation, filtration and adsorption.

Materials and Methods

Sample Collection

The groundwater samples to be analyzed were collected monthly (November, 2015 to October, 2016) from the shallow well. This shallow well was located in Semihtun Village near Yadanabon University as shown in (Fig. 1).Water samples were collected from shallow well using sterile 250 mL plastic bottle.

Analysis of Collected Water Samples

Those properties such as temperature, pH, turbidity, conductivity and color were evaluated by Vernier Lab Pro Instrument(Model: LABQUEST 2, FCIID: AUO- labQUEST 2). Chemical water quality parameters such as total dissolved solids, total alkalinity, total hardness, calcium hardness, nitrite, nitrate, hydrogen sulphide, sulphate, fluoride, free chlorine and total chlorine were analyzed by exact micro 7+ photometer, 525 nm+ 638 nm wavelength (S/N: M 0000793). Phosphate, arsenic, cyanide and copper were determined by exact micro 20 + photometer with blue tooth SMART only , 525 nm + 638 nm wavelength (S/N: M 20 BTA 00009 HACH test kit). Dissolved oxygen, biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were determined by HACH Sension 378HANNA HI 839800 COD Reactor. Biological water quality parameters such as standard plate count, probable coliform count and *Esherichia coli* count were measured by agar plate method.

Treatment of Water Sample

Coagulation

Water sample of 1 liter after plain sedimentation was placed in 1 liter capacity container

and the most suitable dosage of alum coagulant, 40 mg was added into it (Chaw Ei Hlaing, MSc Thesis, 2011). The container was left stagnant condition for 24 hours to settle the sludge. After that, the supernatant clear water was filtered with filter paper to separate from the sludge.

Biofiltration

After coagulation, water sample was passed into biofilter column. It was 6 cm length square shape glass column of 25 cm height, in which water flew down from the top to the bottom and then drained into the outlet pipe (1.5 cm diameter). Each of 4 cm height of broken bricks, gravel, sand and activated charcoal were used as filtering medium and this media were separated by cotton fiber. It was stood on a bench and connected by inlet and outlet pipes as shown in (Fig. 2).

Aeration

Aeration was carried out in an aeration tank, constructed with glass of 1 ft height and 1.5 ft width in which water and air were brought into intimate contact. The aerator was model RS-9800 (Aquarium 3 in 1) with maximum flow rate 2300 liter per hour, made from Zhongshan Electrical Product Co. Ltd, Guangdang, China. Two aerators were used, the one was on the left and another one was on the right. The contact time of air and water support the effective removal of unwanted gases. Air was diffused into an aeration vessel containing counter-current flowing water, creating very small air bubbles to ensure good air-water contact for "scrubbing" of undesirable gases from the water. For effective aeration and removal of undesirable matters in water, aeration time was carried out under sunlight for about 24 hours as shown in (Fig. 3).

Treatment with Activated Charcoal

The treated water sample after aeration was filtered through an activated charcoal media. The fine particles of activated charcoal powder (- 40 +60 mesh) were spread and water was filtered again to remove them. The filtrate was collected and the parameters of water quality were evaluated.

Results and Discussion

The collected groundwater samples from the shallow well in Semihtun Village near Yadanabon University as shown in (Fig. 1) were normally contaminated due to the presence of higher degree of hardness, dissolved impurities and microscopic organisms. Most calcium in groundwater comes from flowing over limestone, CaCO3, gypsum, CaSO4•2H2O, and other calcium-containing rocks and minerals. Groundwater and underground aquifers leach even higher concentrations of calcium ions from rocks and soil. Calcium carbonate is relatively insoluble in water, but dissolves more readily in water containing significant levels of dissolved carbon dioxide. Preliminary measurements were conducted, such as pH, turbidity, total hardness, calcium, magnesium, alkalinity, sulfate, chloride, total dissolved solids and bacteria count. The results were compared with a relevant standard values.

To fulfill the drinking water demand of rural communities, physico-chemical and biological properties of shallow well water were analyzed monthly throughout the year from November 2015 to October, 2016. According to the results shown in (Table. 1),it is obvious that temperature of shallow well water was in the range of 25.6- 31°C, temperature of January (2106) was the lowest and that of June (2016) was the highest. Average temperature, 29.93°C of rainy season (July –October, 2016)was higher slightly than that of summer (2016), 28.65°C (Table. 2). The experimental results of pH values were in the range of 6 - 7.8. In summer (March – June, 2016) was the highest pH value of above 7 and shown in (Table. 1). In all seasons the turbidity of shallow well water was below the allowable values 25 NTU max. (WHO –MONO-49- chp9-13.pdf).The absorbance values indicating the blue, violet, green and red color of water point out that all the colors were not found throughout the year (Table. 2).

One of the important chemical characteristics, observed values of conductivity were much higher than allowable values, 50μS/cm (Free Wikipedia, Conductivity, electrolytic, 2015, pdf)and total dissolved solids in water results were lower than the maximum allowable values 500 mg/L of drinking water standards(EPA, 2011 &2012, Wikepedia, 2016). The values of total alkalinity ,total hardness and calcium hardness values of shallow well water were lower than the maximum allowable values in all seasons (Tables 1 and 2).Although the resultant values of toxic ions, namely the nitrite and nitrate, sulphate, fluoride, free chlorine and total chlorine concentrations in shallow well water were lower than the maximum allowable values of drinking water standards, the concentration of hydrogen sulphide in all seasons was higher than the allowable values (0.05 ppm) of drinking water standards (WHO –MONO-49- chp9-13.pdf and WHO, 2013)because hydrogen sulfide is present in air primarily as a result of natural emissions and also it is derived from natural resources of earth and industrial processes(WHO Guidelines, 1996). The resultant phosphate values were higher than allowable values (0.1 ppm) (WHO Drinking Water Standards (1993). pdf) in rainy and winter seasons. In summer season, the value of phosphate was lower than the maximum allowable value in (Table. 2). As the results in (Table. 2), concentration of cyanide, one of the important hazardous substances was higher than allowable values (0.05ppm) of drinking water standards (WHO, 2013)and its concentration was highest in summer season than winter and rainy seasons. Concentration of arsenic was no observed in all seasons (Fig. 4).

According to the factors mentioned above, chemical oxygen demand (COD) observed values of this shallow well water were below the allowable values (9.99 mg/L)(Free Wikipedia, Conductivity, electrolytic, 2015. pdf and WHO –MONO-49- chp9-13.pdf) in the whole year and biological oxygen demand (BOD) observed values were also lower than the limitations of EPA, 5.99 mg/L(Free Wikipedia, Conductivity, electrolytic, 2015.pdf and WHO –MONO-49- chp9-13.pdf). Observed Dissolved oxygen(DO) values were lower than minimum allowable values (6.0 mg/L) in all seasons (WHO –MONO-49- chp9-13.pdf) where as BOD and COD values were decreased in all season (Fig. 5). As a consequence, the observed values of biological characteristics like standard plate count, Probable Coliform count and *Esherichia coli* count were unsatisfactory for drinking purposes throughout the whole year (Tables 1 and 2).

After analyzing the physico-chemical and biological characteristics of shallow well water, the sequence of available water treatments such as coagulation by alum, filtration through the medium consisting of natural materials such as sand, gravels, charcoal and natural geotextile cotton fiber, followed by aeration under direct sunlight for 24 hours and filtration again by charcoal were conducted to reduce the contaminants in water. The shallow well water sample collected in September, 2016 was treated by the above treatments and the results shown in (Table. 3) point out that the turbidity of treated water was decreased significantly in the sequence of treatments and clear tube well water was obtained. After treatment, the value of conductivity was decreased but higher than the maximum allowable values. The value of total dissolved solid was also decreased below the maximum allowable value. The values of alkalinity, total hardness and calcium hardness of treated water decreased step wisely in the treatments. The observed concentrations of nitrite, sulphate, free chlorine, total chlorine of treated water were also decreased but that of phosphate, nitrate, fluoride and cyanide concentrations reduced considerably below the allowable values. The observed value of hydrogen sulphide was also decreased but slightly higher than the maximum allowable value. After the treatments, the observed values of dissolved oxygen(DO), increased but lower than maximum allowable values whereas biological demand (BOD) decreased below the allowable values and the chemical oxygen demand (COD)decreased slightly(Table. 3) and (Fig. 7). According to the results in (Table. 3),in spite of the aeration for 24 hours under direct sunlight, it was not enough to reduce the microorganisms in water.

By using these treatments of shallow well water in series, the clear water with reduced concentrations of some toxic substances within the allowable values for drinking purposes was obtained, although the available treatments have some weakness.

Figure (1). Water Sampling Point in Semihtun Village
Source: From Google Earth
Sampling point(N Lat 21º 53' 30", E long 96º 03'59")

Table (1). Comparisons of the Characteristics of Shallow Well Water During the Whole Year near Yadanabon University, Semihtun Village, Mandalay City (2015-2016)

Characteristics	Months (2015-2016)											
	Winter				Summer				Rainy			
	Nov.	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**April**	May	June	July	Aug.	Sept.	Oct.
Physical												
Avg.Temp., ºC	28.1	26.8	25.6	26.2	26.7	28	29	31	30.6	30.3	29.6	29.2
pH	6.2	6.9	7.65	7.5	7.4	7.3	7.2	7.8	6.9	6.0	6.4	6.8
Turbidity, NTU	18.9	14.3	9.8	10.7	11.2	12.4	13.6	17.3	20.8	24.3	23.9	23.5
Color: absorbance Violet	0	0	0	0	0	0	0	0	0	0	0	0
Blue	0	0	0	0	0	0	0	0	0	0	0	0
Green	0	0	0	0	0	0	0	0	0	0	0	0
Red	0	0	0	0	0	0	0	0	0	0	0	0
Chemical												
Conductivity, µS/cm	256.2	263.5	271	270	268.5	260	252	240	238.4	237	237	236
Total Dissolved Solids, mg/L	163.9	168.6	173.4	172.3	171.3	163.7	156.2	153.4	152.5	151.6	151.7	151.8
Total Alkalinity, mg/L	200	195	189	187.5	186	150	114	116	147	178	170	161.2
Total Hardness, mg/L	444	349.5	255	263.5	272	276.5	281	292	190.5	89	91	92
Calcium Hardness, mg/L	45	44	43	43	43	43	42	44	39	34	39	44
Phosphate, ppm	0.38	0.21	0.03	0.03	0.03	0.03	0.03	0.03	0.2	0.28	0.3	0.33
Nitrite, ppm	0.04	0.03	0.01	0.02	0.02	0.03	0.03	0.08	0.07	0.06	0.06	0.05
Nitrate, ppm	1.16	0.7	0.1	0.1	0.1	0.1	0.1	0.1	0.8	1.5	1.3	1.17
Hydrogen Sulphide, ppm	0.6	0.35	0.1	0.2	0.28	0.28	0.27	0.32	0.38	0.44	0.46	0.48
Sulphate, ppm	191	178	165	167	172	179	186	199	139	139	134	189
Fluoride, ppm	0.2	0.2	0.2	0.2	0.2	0.22	0.24	0.21	0.2	0.2	0.2	0.2
Free Chlorine, ppm	0.03	0.02	0.01	0.01	0.01	0.02	0.02	0.36	0.27	0.19	0.1	0.01
Total Chlorine, ppm	0.12	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.15	0.28	0.2	0.1
DO, mg/L	4.6	5.38	5.1	5.6	5.6	5.6	5.4	5.01	5.01	5.01	5.0	5.0
BOD, mg/L	3.9	4.35	4.8	4.9	4.9	4.91	4.91	4.9	4.88	4.85	4.81	4.76
COD, mg/L	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.61	9.62	9.62	9.61	9.6
Cyanide, ppm	0.12	0.1	0.02	0.02	0.02	0.02	0.03	0.04	0.06	0.13	0.06	0.06
Arsenic, ppm	0	0	0	0	0	0	0	0	0	0	0	0
Biological												
Standard Plate Count ,mpn	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300	>300
Probable Colifo-rm Count	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5
Esherichia coli Count	Isolat-ed	Isolat-ed	Isolat-ed	Isolat-ed	Isolat-ed	Isolat-ed	Isolat-ed	Isolat-ed	Isolat-ed	Isolat-ed	Isolat-ed	Isolat-ed

Note: BOD, COD, DO and Arsenic content were determined at laboratory, Mandalay City Development Committee, Mandalay. Biological characteristics were determined at laboratory, Public Health Department (Upper Myanmar), Mandalay

Table (2). Comparisons of the Characteristics of Shallow Well Water During Summer, Rainy and Winter Seasons near Yadanabon University, Semihtun Village, Mandalay City (2015-2016)

Characteristics	**Months (2015-2016)**			**Allowable Values ***
	Winter	**Summer**	**Rainy**	
	Nov.,Dec., Jan.,Feb.	**Mar.,April, May,June**	**July,Aug., Sept.,Oct.**	
Physical				
Avg.Temp.,°C	26.67	28.65	29.93	-
pH	7.06	7.42	6.52	7.0
Turbidity, NTU	13.42	13.63	23.13	25 Max.
Color: absorbance Violet	0	0	0	-
Blue	0	0	0	-
Green	0	0	0	-
Red	0	0	0	-
Chemical				
Conductivity, µS/cm	265.15	255.15	237	50
Total Dissolved Solids, mg/L	169.56	161.15	151.9	500 Max
Total Alkalinity, mg/L	192.87	141.5	164	200 Max.
Total Hardness, mg/L	328	280.37	115.75	500Max.
Calcium Hardness, mg/L	43.75	43	39	150Max.
Phosphate, ppm	0.16	0.03	0.27	0.1 Max.
Nitrite, ppm	0.03	0.04	0.06	0.5 Max.
Nitrate, ppm	0.51	0.1	1.19	10.0 Max.
Hydrogen Sulphide, ppm	0.31	0.28	0.44	0.05 Max.
Sulphate, ppm	175.25	183	150.25	200 Max.
Fluoride, ppm	0.2	0.26	0.2	1.5 Max.
Free Chlorine, ppm	0.02	0.1	0.14	4.0 Max.
Total Chlorine, ppm	0.05	0.01	0.18	4.0 Max.
DO, mg/L	5.17	5.39	5.04	6.0 Min.
BOD, mg/L	4.49	4.91	4.82	5.99 Max.
COD, mg/L	9.61	9.6	9.61	9.99 Max.
Cyanide, ppm	0.06	0.08	0.06	0.05Max.
Arsenic, ppm	0	0	0	0.01Max.
Biological				
Standard Plate Count, mpn	>300	>300	>300	<600
Probable Coliform Count	5/5	5/5	5/5	50 Max.
Esherichia coli Count	Isolated	Isolated	Isolated	-

***Source:** United States Environmental Protection Agency (2011), *EPA 820-R-11-002*,
World Health Organization(2013),Standards of Potable water Quality and Water-Borne Diseases, Geneva
World Health Organization(2015), Drinking Water Quality Standards , Geneva.

Table (3). Comparisons of the Characteristics of Shallow Well Water near Yadanabon University, Semihtun Village, Mandalay City Before and After Treatments

Characteristics	**September ,2016**					**Allowable Values ***
	Before Treatment	**After Coagulation**	**After 1st Filtration**	**After Aeration**	**After 2nd Filtration**	
Physical						
Avg.Temp.,ºC	29.6	30	30	30	30	-
pH	6.4	6.2	6.2	6.1	6.1	7.0
Turbidity,NTU	23.9	1.0	-5.2	-5.2	-9.9	25 Max.
Absorbance: Violet	0	0	0	0	0	-
Blue	0	0	0	0	0	-
Green	0	0	0	0	0	-
Red	0	0	0	0	0	-
Chemical						
Conductivity, µS/cm	237	221	199	189	181	50
Total Dissolved Solids,mg/l	151.7	149.2	146.7	138	132	500 Max
Total Alkalinity,mg/l	170	152	151	139	130	200 Max.
Total Hardness,mg/l	91	88	82	72	70	500Max.
Calcium	39	32	31	28	26	150Max.
Phosphate,ppm	0.3	0.28	0.21	0.19	0.1	0.1 Max
Nitrite,ppm	0.06	0.05	0.05	0.05	0.04	0.5 Max.
Nitrate,ppm	1.3	1.2	1.2	0.1	0.09	10.0 Max.
Hydrogen Sulphide	0.46	0.40	0.32	0.12	0.07	0.05 Max.
Sulphate,ppm	134	128	119	117	96	200 Max.
Fluoride,ppm	0.2	0.08	0.06	0.06	0.04	1.5 Max.
Free Chlorine, ppm	0.1	0.09	0.06	0.06	0.06	4.0 Max.
Total Chlorine, ppm	0.2	0.16	0.14	0.12	0.09	4.0 Max.
DO ,mg/l	5.0	-	-	-	5.2	6.0 Min.
BOD,mg/l	4.81	-	-	-	2.28	5.99 Max.
COD,mg/l	9.61	-	-	-	9.0	9.99 Max.
Cyanide,ppm	0.06	0.04	0.04	0.01	0.01	0.05Max.
Arsenic,ppm	0	0	0	0	0	0.01Max.
Biological						
Standard Plate Count	>300	>300	>300	>300	>300	<600
Probable Coliform	5/5	5/5	5/5	5/5	5/5	50 Max.
Esherichia coli	Isolated	Isolated	Isolated	Isolated	Isolated	Isolated

***Source:** United States Environmental Protection Agency (2011), *EPA 820-R-11-002*
World Health Organization (2013), Standards of Potable water Quality and Water-Borne Diseases, Geneva
World Health Organization (2015), Drinking Water Quality Standards, Geneva.

Figure (2). Biofiltering Column

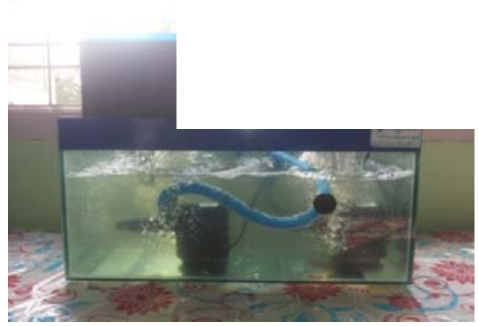

Figure (3). Aeration Tank

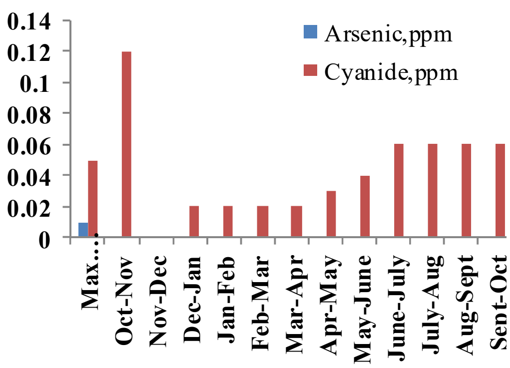

Figure (4). Comparison on Arsenic and Cyanide Content of Shallow Well Water in All Seasons

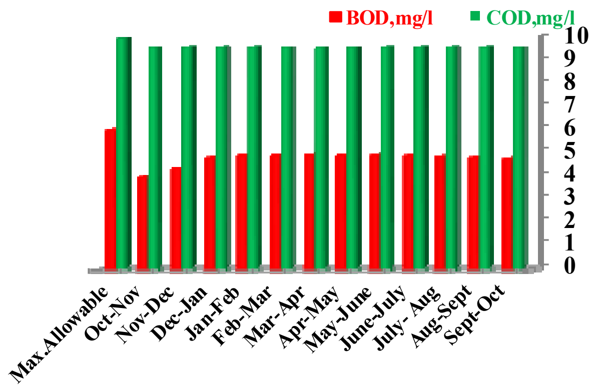

Figure (5). Comparison on BOD and COD of Shallow Well Water in All Seasons

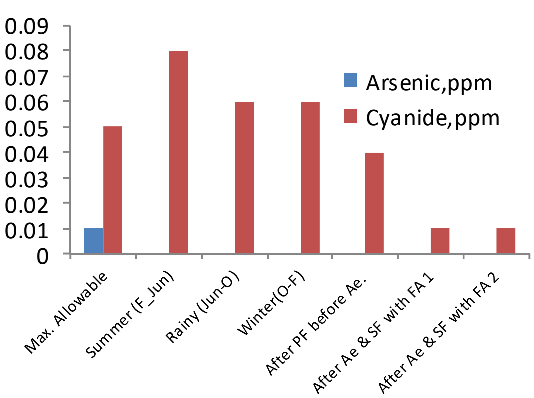

Figure (6). Comparison on Arsenic and Cyanide Content of Shallow Well Water in All Seasons and After Treatments

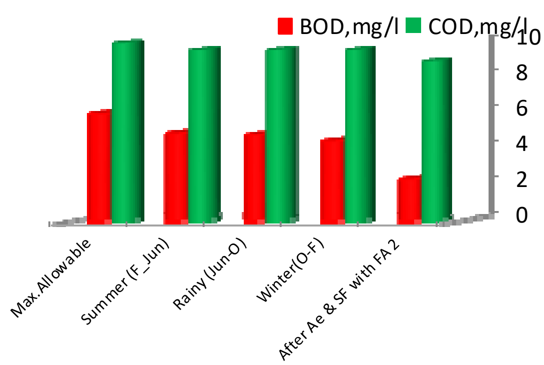

Figure (7). Comparison on BOD and COD of Shallow Well Water in All Seasons and After Treatments

Conclusion

This is the first effort of the detailed investigation of shallow well water quality monthly from November, 2015 to October, 2016 near Yadanabon University, and readily available inexpensive water treatments for rural people were carried out. It is concluded that by contributing this low cost technology, the poor people could get the knowledge for the better clean water. They could build the makeshift water treatment column and aerators to get good clean water for drinking purposes. In many areas of the world, shallow wells have proven very effective due to their locally available technology and low cost. Where well constructed and fitted with hand-pumps, they have proven sustainable in supplying potable water. However the treatments of shallow well water have requirements to improve the better quality of drinking water, the results of this research would be implemented in some way to get the safe drinking water for poor peri-urban communities.

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