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Assessment of Water Quality of Shallow Wells from Rural Areas for both Domestic and Irrigation Uses

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ABSTRACT

This paper presents the assessment of water quality of shallow wells from rural areas for both domestic and irrigation uses. Twenty (20) shallow wells water samples were analyzed in both rainy season and dry season, for Physico-chemical parameters as pH meter, electric conductivity µs/cm, total hardness mg/l, total alkalinity mg/l, dissolved oxygen mg/l, chemical oxygen demand mg/l, with Bacteriological analysis which shows that all the water samples have traces of E.coli (cfu/ml), total coliform (cfu/100ml) and total bacterial count (cfu/ml) except in station (10) in the dry season which the total coliform does not exceed the World Health Organization (WHO) limit for drinking. The average water quality index (WQI) of 75.22 for rainy season and 57.83 in dry season indicates that the untreated well water from rural areas in Katcha local government of Niger state is of fair quality and however must be treated before use to avoid water borne diseases. The results of this research recommend that the shallow wells water from the rural areas are not suitable for drinking in any season but can be used for irrigative uses and therefore appropriate measures should be taken before consumption.

Keywords: Bacteriological parameters, Physico-chemical parameters, shallow wells, Water quality index,

1. INTRODUCTION

Shallow well is a pit dug to the groundwater table manually. The requirement of clean and sustainable quality of water cannot be over emphasized as it is of great important for human survival. An agricultural purpose such as irrigation also requires enough water supplies from a good recharge but due to the unavailability of good water sources, the rural communities rely in hand dug well water. Water is no doubt one of the most essential resources on earth and remains man's prime need in his environment. It is also a fact that portable water supply is of shortage or lacking in many communities' despite being one of the most available resource on universe. Due to rapid growth in technology the extensive use of chemical fertilizers for Agriculture are some of the factors that have direct effects on the quantity and quality of groundwater resources.

According to Mustapha and Yusuf (1999), poor water quality can pose health problem enough to threaten human life if consumed. Humans may survive for several weeks without food, but barely few days without water because constant supply of water is needed to replenish the fluid lost through normal physiological activities, such as respiration, perspiration, urination, (Chinedu *et al*., 2011). The pollution of ground water sources may be from industries, agricultural and domestic wastes. However, Chukwurah (2016) said World Health Organization (WHO,2015) recommended that wells should be located at least 30 m away from latrines and 17 m from septic tanks.

However, according to Okafor, 1985; Okpokwasili and Akujobi, (1996), the presence of faecal coliforms or *Escherichia coli* is an indicator for the presence of water borne pathogens. Bacteriological examination of water is therefore a powerful tool in order to foreclose the presence of micro-organisms that might constitute health hazards (Singh and Neelam, 2011). However, World Health Organization (WHO) recommended that no faecal coliform should be present in 100 ml of drinking water. Good quality water should be odourless, colourless, tasteless and free from faecal contamination and chemicals in excess of WHO tolerable levels.

Insufficient solid waste management is a vital environmental problem in rural community, the contributing factors ranged from technical problem to educational and financial limitations. The challenge of appropriate refuse disposal (solid waste) is immensely and has become very serious problem. Unfortunately, most of the refuse is permanently disposed at groundwater recharge points, open space or burrow pits, pit latrines, septic tanks for human wastes. Effluent is admitted through the major drainage networks and finally emptied into river with the negative impact on groundwater and the environment. This study is to assess the bacteriological quality of hand dug well for both domestic and irrigative purposes in the rural area to ascertain the danger of contamination that may be present in such type of wells and as well as it effects to human health.

2. MATERIALS AND METHODS

2.1 Sample collection

The shallow well water was collected from Katcha local government area of Niger state from the following villages;

1. Echegi
2. Zhitu
3. Katch Iraba
4. Katcha Kpata
5. Yintu

2.2 Groundwater Sampling

Representative samples of groundwater was collected from 10 shallow well water from 5 locations for each season that is from October to December, 2019 based on distribution of the wells that represent groundwater and permission from owners prior to sampling. The water was collected in 1 litre plastic containers before collection as part of quality control measures all the bottles were washed with non – ionic detergent and rinsed with de – ionized water prior to usage, for DO and BOD re agent was added to the water sample immediately at the site. The sampling bottles were rinsed three times with well waters at the point of collection. Each bottle was labeled according to sampling location to avoid mixing error and was carefully preserved at 4^oC and transported directly the laboratory for analysis.

2.3 Sample Preparation and analysis

2.3.1 Physico-chemical analysis

The following processes were carried out after each sample was collected, standard methods and procedures were adopted (APHA, 1992) to conduct the analysis. An in- situ measurement was K made for conductivity, pH, and temperature using Sension Platinum Series, portable pH and conductivity meter (HACH made). The samples were poured into the measuring bottle and the surface or the bottle was wiped with silicon oil. The bottle was then inserted into the turbid meter and the reading was obtained. The water samples for anion analysis were filtered using a hand operated vacuum pump equipped with a 0.45µm cellulose acetate filter membrane. Bicarbonate (HCO_3) was carried out using acid titration, with methyl orange as indicator. Nitrate (NO_3), phosphate (pO_4^{2-}) were determined using V2000 multi – analyte photometer, Na and K were carried out with a CORNING FLAME PHOTOMETER 410 after calibrating it with analyte standard while the remaining Trace and heavy metals were carried out with a Varian model AA240FS Fast Sequential Atomic Absorption Spectrometer.

2.4 Calculations of Water quality index

The calculation of the WQI will be done using weighted arithmetic water quality index which was originally proposed by Horton (1965) and developed by Brown et al (1972). The weighted arithmetic water quality index (WQI_A) is in the following form:

$$WQI_A = \Sigma wiqi\ ni=1 / \Sigma wini=1 \qquad (1.1)$$

Where n is the number of variables or parameters, wi is the relative weight of the ith parameter and qi is the water quality rating of the ith parameter. The unit weight (wi) of the various water quality parameters are inversely proportional to the recommended standards for the corresponding parameters. According to Brown et al (1972), the value of qi is calculated using the following equation:

qi= 100 [(Vi – Vid) / (Si – Vid) (1.2)

Where Vi is the observed value of the ith parameter, Si is the standard permissible value of the ith parameter and Vid is the ideal value of the ith parameter in pure water. All the ideal values (Vid) are taken as zero for drinking water except pH and dissolved oxygen (Tripaty and Sahu, 2005). For pH, the ideal value is 7.0 (for natural/pure water) and a permissible value is 8.5 (for polluted water). Therefore, the quality rating for pH is calculated from the following equation:

qpH = 100 [(VpH – 7.0) /(8.5 – 7.0)] (1.3)

Where VpH = observed value of pH.

For dissolved oxygen, the ideal value is 14.6 mg/L and the standard permissible value for drinking water is 5 mg/L. Therefore, its quality rating is calculated from the following equation:

qDO = 100 [(VDO– 14.6) / (5.0 – 14.6)] (1.4)

Where VDO = observed value of dissolved oxygen.

Table 2.1. Summary for water quality index (WQI) and corresponding water quality status (WQS)

S/**No**	**WQI**	**WQS**	**Possible Uses**
1	0-25	Excellent	Drinking, Irrigation and Industrial
2	26-50	Good	Domestic, Irrigation and Industrial
3	51-75	Fair	Irrigation and Industrial
4	76-100	Poor	Irrigation
5	101-150	Very Good	Restricted use for Irrigation
6	>150	Unfit For Consumption	Proper Treatment Essential before use

Source: www.rjibpcs.com

4.0 RESULTS AND DISCUSSIONS

Table 4.1. Physico-chemical analysis of shallow well water in rainy season

	(STATIONS)											
Parameters	1	2	3	4	5	6	7	8	9	10	WHO	FAO
Temp.(ºC)	28	29	28	28	28	29	28	28	28	28	30-35	3.5-13
P_H	6.41	6.51	6.49	6.46	6.43	6.45	6.80	6.20	6.60	7.17	6.5-7.5	7.0-8.0
EC (µs/cm)	386	350	592	543	566	539	323	586	383	420	300	700-3000

TH (mg/l)	224	168	260	188	172	162	168	174	136	152	500	-
TA (mg/l)	78	64	77	64	44	32	30	26	34	26	500	-
DO (mg/l)	8	5	6	6	8	6	6	5	7	9	5.0	-
COD (mg/l)	14.6	12.18	16.25	15.11	15.86	15.30	12.65	17.42	12.65	14.28	2000-6000	-
BOD (mg/l)	2	3	4	4	4	4	4	3	4	5	0-5	15
PO_4 (mg/l)	0.63	0.46	1.38	1.22	1.54	1.36	0.76	2.04	0.53	0.85	-	0-2
NO_3 (mg/l)	5.82	4.16	6.25	5.75	6.46	6.22	3.71	6.38	3.55	4.27	50	30
Na (mg/l)	14.65	13.81	17.25	23.17	28.35	25.17	20.78	17.12	19.36	18.62	50	200
k (mg/l)	3.85	3.22	5.7	8.35	6.72	5.85	4.21	5.33	4.65	3.97	55	20
Ca (mg/l)	56.48	59.71	66.23	54.15	72.36	38.81	45.98	40.26	48.30	51.13	75	100
Mg (mg/l)	14.22	18.75	22.81	16.52	21.38	10.74	16.30	14.18	16.36	12.74	150	50
HCO_3(mg/l)	37.63	30.41	36.66	29.38	20.10	13.92	12.88	10.82	14.95	10.82	1000	125
Fe (mg/l)	2.85	1.93	3.58	3.12	3.65	3.72	1.95	4.44	2.11	3.26	0.3	5.0
Mn (mg/l)	1.13	0.81	2.33	1.65	1.44	1.81	0.36	2.52	1.16	1.74	0.1	0.20
Cu (mg/l)	0.11	0.11	0.31	0.28	0.33	0.13	0.05	0.42	0.13	0.16	1.0	0.20
Pb (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01	5.0
Zn (mg/l)	0.06	0.04	0.10	0.1	0.1	0.1	0.05	0.13	0.07	0.09	5.0	2.0

Table 4.2. Physico-chemical analysis of shallow well water in dry season

	(STATIONS)											
Parameters	1	2	3	4	5	6	7	8	9	10	WHO	FAO
Temp.(ºC)	30	30	29	30	29	30	30	29	30	30	30-35	3.5-13
PH	7.16	6.68	6.50	6.28	6.36	6.45	6.36	6.44	6.46	6.40	6.5-7.5	7.0-8.0
EC (μs/cm)	69	66	76	288	413	402	400	408	396	400	300	700-3000
TH (mg/l)	192	148	136	176	150	146	160	166	130	144	500	-
TA (mg/l)	74	84	78	90	78	86	104	114	80	96	500	-
DO (mg/l)	6	5	6	6	5	5	6	8	5	5.4	5.0	-
COD (mg/l)	7.28	5.9	5.55	6.2	7	7.36	7.18	7.22	6.98	7.58	2000-6000	-
BOD (mg/l)	4	2	3	3	2	3	4	3	2.4	3	0-5	15
PO_4 (mg/l)	0.16	0.18	0.12	0.65	0.22	0.20	0.18	0.23	0.19	0.17	-	0-2

NO_3 (mg/l)	0.35	0.42	0.24	1.34	1.84	2.22	1.65	1.33	1.75	1.42	50	30
Na (mg/l)	5.2	6.83	5.9	8.7	7.6	9.2	9.6	8.8	7.2	9.3	50	200
k (mg/l)	1.8	2.6	1.7	2.3	2.1	3.5	3.3	3.1	2.2	3.4	55	20
Ca (mg/l)	24.66	18.75	22.78	29.44	38.47	36.44	34.58	42.77	46.92	44.75	75	100
Mg (mg/l)	5.36	4.22	4.88	6.26	7.75	5.98	5.24	7.36	5.86	6.13	150	50
HCO_3(mg/l)	35.56	40.72	37.63	43.81	37.62	41.75	51.03	56.19	38.66	46.91	1000	125
Fe (mg/l)	0.38	0.42	0.24	1.32	1.84	2.22	1.65	1.33	1.75	1.42	0.3	5.0
Mn (mg/l)	0.01	0.01	0.46	0.49	0.65	0.48	0.39	0.55	1.33	1.16	0.1	0.20
Cu (mg/l)	0.04	0.03	0.03	0.16	0.13	0.21	0.18	0.41	0.35	0.32	1.0	0.20
Pb (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01	5.0
Zn (mg/l)	0.01	0.01	0.01	0.18	0.22	0.16	0.30	0.26	0.22	0.28	5.0	2.0

Table 4.3. Classification of ground water hardness (Sawyer and McCarty, 1967)

Hardness range (mg/l of CaCo3)	Water classification
0-75	Soft
75-150	Moderate
150-300	Hard
>300	Very hard

Table 4.4. Bacteriological analysis of shallow wells water in rainy season

Parameters/ Stations	E. coli (cfu/ml)	Total coliform (cfu/100ml)	Total bacterial count (cfu/ml)
1	14×10^6	26	48×10^6
2	15×10^6	79	52×10^6
3	12×10^6	8	47×10^6
4	10×10^6	26	70×10^6
5	14×10^6	180	68×10^6
6	12×10^6	26	42×10^6
7	12×10^6	350	46×10^6
8	10×10^6	5	49×10^6
9	9×10^6	17	63×10^6
10	10×10^6	11	69×10^6
WHO	0	10	0-100

Table 4.5. Bacteriological analysis of shallow wells water in dry season

Parameters/ Stations	E. coli (cfu/)	Total coliform (cfu/100)	Total bacterial count(cfu/ml)
1	10×10^6	30	41×10^6
2	12×10^6	80	50×10^6
3	7×10^6	3	38×10^6
4	3×10^6	20	40×10^6
5	10×10^6	100	68×10^6
6	9×10^6	20	31×10^6
7	10×10^6	300	29×10^6
8	4×10^6	2	36×10^6
9	7×10^6	12	13×10^6
10	4×10^6	10	69×10^6
WHO	0	10	0-100

Source: laboratory analytic data, 2012

Summary of statistical variations of Physico-chemical parameters using Water Quality Index (WQI) for both rainy and dry seasons

Table 4.6. Statistical analysis of rainy season stations (WQI totals)

Stations	WQI
1	55.07
2	64.74
3	88.23
4	83.38
5	80.35
6	85.00
7	72.21
8	89.85
9	42.97
10	90.41
	Average =75.22

Table 4.7. Statistical analysis dry season stations (WQI totals)

Stations	WQI
1	50.07
2	37.60
3	39.24
4	54.89
5	63.84
6	68.65
7	69.89
8	61.54
9	65.45
10	67.1
	Average = 57.83

Graphical variations of the rainy and dry season parameters

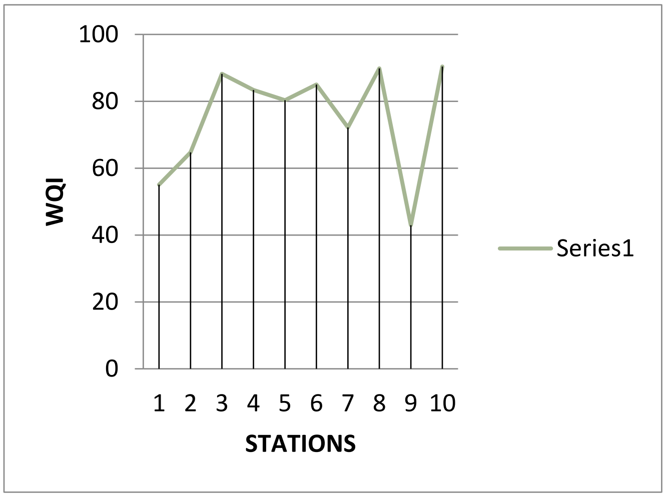

Chart 4.0 Rainy season parameters

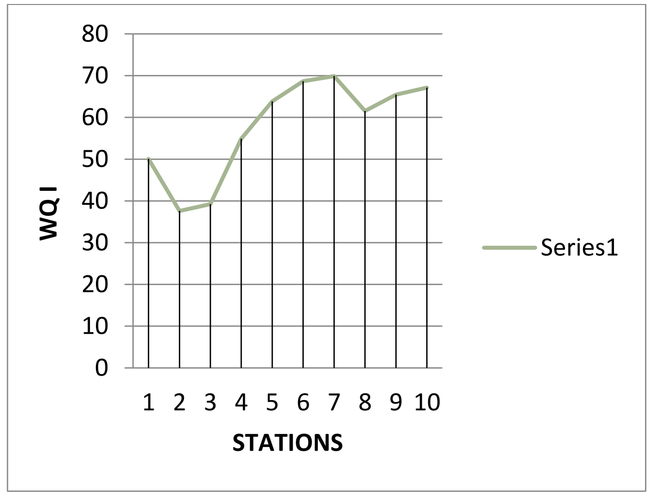

Chart 4.1 Dry season parameters

4.1 Discussion of Results

4.1.1 Physico-chemical analysis of shallow wells water for rainy season

The physico-chemical analysis of shallow well water shows different results from the tables above, table 4.1 shows the Physico-chemical parameters of (10) shallow well water during the rainy season with station 2 and 6 having the highest temperature and the rest stations having the lowest temperature of 28^0C respectively, station 3 is having the highest electrical conductivity (Ec) with station 7 having the lowest Ec, as station 1 is having the highest TH and TA with station 9 having the lowest TH and 8 and 10 having the least TA, while station 2 and 8 are having the lowest DO and station 10 is having the highest DO, station 8 having the highest COD with station 2 having the lowest COD whereas station 1 is having the lowest BOD with station 10 as the highest and station 2 is having the lowest PO_4 follow by station 9 with 8 having the highest PO_4 and also station 5 is having the highest NO_3 and Na, but station 9 which has the lowest NO_3 with station 1 having the lowest Na, and station 2 having the lowest K with station 4 having the lowest K as station 5 is having the highest Ca with station 6 having the lowest Ca and Mg while station 2 is having the highest Mg, station 1 and is having the highest HCO_3 with station 8 and 10 having the lowest HCO_3, and station 10 is having the lowest Fe with station 7 having the highest Fe, but has the lowest Mn and Cu with station 8 having the highest Mn and Cu. Pb has no presence in all the stations in the test carried out therefore station 2 has the lowest Zn with station 8 having the highest Zn. All the P^H of the stations met up the WHO and FAO standards, but failed to meet up electric conductivity (Ec) standard for both WHO and FAO. TH, TA, standard did not meet up WHO and FAO except for DO which meet up WHO standard only. COD, BOD was not meet up for all the stations except for PO_4 which most of the stations meet up FAO standard except station 8. NO_3, Na, K, Ca, Mg, HCO_3 Fe, Mn, Cu, Pb, and Zn standard for World Health Organization (WHO) and Food and Agriculture Organization for United Nations (FAO) were not met up respectively.

4.1.2 Physico-chemical analysis of Hand dug wells water for dry season

From table 4.2 it can be seen that the P^H of station 7 is the highest with station 4 having the lowest, station 5 is having the highest Ec with station 2 having the lowest Ec, the TH of station 1 is the highest with station 9 having the lowest TH, and station 1 is also having the lowest TA with station 8 having the highest TA, DO of station 8 is the highest with station 2, 5,6 and 9 having the lowest DO, while station 10 has the highest COD with lowest station in 3 and the highest BOD appears in 1 and 7 with station 2 and 6 are having the lowest BOD, PO_4 of station 8 is the highest with station 3 having the lowest PO_4 whereas station 6 NO_3 is the highest with station 2 having the lowest, while the Na of station 7 is the highest with the lowest in station 1, station 9 having the highest Ca with station 2 as the lowest whereas station 5 is having the highest Mg with station 3 having the lowest Mg, the HCO_3 of station 8 is the highest with station 1 as the lowest, but Fe of station 3 is the lowest with station 6 as the highest, whereby station 1 and 2 are having the lowest Mn with station 8 having the highest, station 1, 2 and 3 are having the lowest Cu with station 8 as the highest but Pb was not detected in all the stations however station 10 is having the highest Zn with station 1, 2 and 3 appearing with the lowest Zn. all the P^H of the stations are within WHO standard and FAO range but none of them meet up to Electrical conductivity standard for WHO and FAO, TH, TA, DO standard for WHO did not meet up to standard as there is no standard of these parameter for FAO, therefore all the stations did not meet up BOD standard for both WHO and FAO, as there is no WHO standard for PO_4 although the stations are within FAO standard range except station 5 which is above standard for the PO_4, NO_3, K, Ca, Mg, HCO_3. Fe did not meet up WHO and FAO standard, and also Mn, Cu and Zn with no detection of Pb in all the stations.

4.1.3 Bacteriological analysis of shallow wells water in rainy season

From table 4.4 it has been seen that none of the stations meet up the World Health Organization (WHO) standard except station 3 and 8 which are below standard of WHO under total coliform only with the rest of the station been above standard.

4.1.4 Bacteriological analysis of shallow wells water in dry season

Table 4.5 shows station 3 and 8 are below WHO standard also for total coliform with all the rest stations been above World Health Organization (WHO) standard under E.coli, total coliform and total bacterial count with only station 10 that meet up to world health organization (WHO) standard under total coliform.

4.1.5 Water quality index (WQI) for shallow well water in rainy season

Table 4.6 above shows the summary of statistical analysis of rainy season stations with the observe values (vi) of physico-chemical parameters of ten (10) selected stations, standard drinking water values (si) according to world health organization (WHO, 2017), unit weight (wi), water quality rating (qi) and wiqi. Station 1 having WQI value as 55.07 means that the water quality status is fair in terms of index number and therefore unfit for drinking and domestic uses but can be used for irrigation and industrial purposes, station 2 is having WQI value of 64.74 is fair and classified as station 1 above, station 3 WQI value is 88.23 is poor and classified as poor and unfit for both drinking and domestic uses but can only be used for irrigational purposes, whereas station 4 WQI value is 83.38 is poor in terms index number, station 5 WQI value is 80.35, station 6 WQI value is 85.00, which are classified as poor, station 7 having the WQI value of 72.21 is fair, that it is unfit for consumption and domestic uses but can be used for irrigation and industrial, station 8 WQI value is 89.85 is poor under water quality classification and unfit for both drinking and domestic uses but usable for irrigational use only while station 9 with WQI value of 42.97 is good according to water quality classification that is can be used for domestic, irrigation and industrial purposes, however station 10 with WQI value as 90.41is classified as poor and unfit for consumption and domestic uses but can serve irrigation uses only. The overall average is 75.22 which mean that the selected stations during the rainy season is poor in terms of water quality index number and can only be used for irrigation.

4.1.6 Water quality index for shallow well water in dry season

From table 4.7 above station 1 is having WQI of 50.07 is good in terms of index number and fit for domestic, irrigation and industrial uses, station 2 having WQI value of 37.60 and station 3 with WQI value of 39.24 are good and classified as station 1, while station 4 is having WQI value of 54.89 is fair in terms of index number, unfit for drinking and domestic purposes, station 5 has 63.85, station 6 has 68.65, station 7 has 69.89, station 8 has 61.54, station 9 has 65.45 and finally station 10 has 67.10 as WQI values which are fair in term of water quality index number and therefore can only be used for irrigation and industrial uses. The overall average of the station is 57.83 which simply mean that the Hand dug wells water cannot be used for drinking and domestic purposes but can serve for irrigation and industrial uses during the dry season.

5.1 CONCLUSIONS

The Physico-chemical and bacteriological analysis of the shallow wells water in the study area (katcha) shows that the well water are not safe for consumption as a result of presence of some harmful bacterial which can cause water borne diseases to human health as there is no adequate and safe drinking water, although 95% of the well water is good for irrigational purposes. Water quality index (WQI) indicates the water quality in terms of index number which presents useful information of the overall quality of the water for public or for any other utilities as well as water quality management in order to access it suitability for drinking purposes. The average water quality index (WQI) of 75.22 for rainy season and 57.83 in dry season indicates that the untreated shallow well water in the rural areas from Katcha in Niger state is of fair quality and however must be treated before use to avoid water borne diseases.

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