PHYSICO-CHEMICAL CHARACTERIZATION OF RIVER PRA IN THE WESTERN REGION, GHANA

Braimah Seth and Bentil John

ABSTRACT-This research was carried out to assess the physico-chemical characteristics of River Pra. A total of eight (8) water samples were collected from four (4) selected communities. Laboratory analysis was performed on nineteen (19) physico-chemical parameters to determine the current state of the River. The results revealed that pH,salinity,conductivity,totalalkalinity,nitrate,nitrite,phosphate,ammonia,chloride,zinc,chromium and arsenic were within the permissible limits of WHO and EU.However, the mean concentration of colour,turbidity,mercury,lead,copper and total iron were above the permitted limits of WHO and EU standards for drinking water, which pose high threat to consumer. It is therefore suggested that small scale miners and illegal miners should be stopped from carrying out their activities in the Pra River.

Index Terms: Characterization, Drinking Water, Pra River, Physico-chemical parameters, Pollution, raw water, Water quality

1 INTRODUCTION

GLOBALLY, water is one essential commodity needed for the sustenance of life on planet earth. History reveals that life originated from water and it can only be sustained with adequate water. Water is the life line of all life forms. Pollution of water by increased industrialization and improper disposal of waste in the environment is a wide spread global concern. But freshwater resources are limited and fragile. Therefore, the quality of raw water and drinking water sources cannot be left unprotected from various contaminations. It is estimated that about 80% of all the reported cases of disease in the developing world have been attributed to lack of safe drinking water and improved sanitation[1].

If surface water were totally unaffected by human activities, up to 90-99 percent of global fresh water would have natural chemical concentrations suitable for aquatic life and most human uses. But, anthropogenic activities such as uncontrolled land use, illegal mining activities, change of untreated waste and excessive use of fertilizer and pesticides are directly and indirectly affecting the aquaticenvironment [2].Monitoring of water quality leads to management and conservation of aquatic ecosystem.

With the advent of industrialization and increasing population, the requirements for water have increased together with greater demand for higher water quality [3].Due to the inaccessibility of quality drinking water, some communities in the developing countries depend on raw water sources as their main drinking water sources. But due to the solvent properties of water, many substances may be found in solution in natural water bodies and some are potentially hazardous to human and aquatic life.

Report by Ghana Water Company Limited [4], revealed traces of cancer causing chemicals in the Pra River which serves both as a raw water and drinking water source for some surrounding communities. These make the water quality of the Pra River to be indispensable.

Consequently, the characterization of River Pra, a raw water source and a source of water supply for some communities in the Western Region of Ghana is needed. The main objective of this research is to assess the physico- chemical parameters of River Pra to determine the current state to aid better management and conservation.

Author Braimah .S, is currently working as Lecturer at Takoradi Polytechnic Institute, Department of Civil Engineering, Ghana. E-mail: Seth.braimah@tpoly.edu.gh

Co-author Bentil.J, is currently working as senior Lecturer at Takoradi Polytechnic Institute, Department of Civil Engineering, Ghana. E-mail:John.bentil@tpoly.edu.gh

2 Experimental Works

2.1 Background of study area

River Pra is located between latitude (50°- 70°30'N) and longitude (20°30'- 00°30'W) in south-central Ghana. Its upper reaches sources from highlands of Kwahu Plateau in the Eastern Region and flows for some 240km before entering the Gulf of Guinea near Shama in the Western Region.The study area is bounded in the latitude as (005°- 005°04'N) and longitude (001°40'- 001°35'W) as shown in **Fig.1**. Its main tributaries include Offin,Anum, and Bisim Rivers. Administratively, the Pra River covers 41 district drainage area of about 22,106km^2 and elevation of 300m which is generally less than 600m above mean sea level along the river. Land use is predominately agriculture. It serves as a major source of water supply to communities along the river. However, human activities such as mining (mostly illegal) and logging are having adverse impacts and degrading the quality of the surface resource of the river. Also, pollution by unapproved fishing methods and the use of agrochemical in vegetable farming along the river are damaging the potential and the ability of the river to support plant, animals, human as well as aquatic life thus making it unsafe for domestic use and unhealthy to support the ecosystem[5].

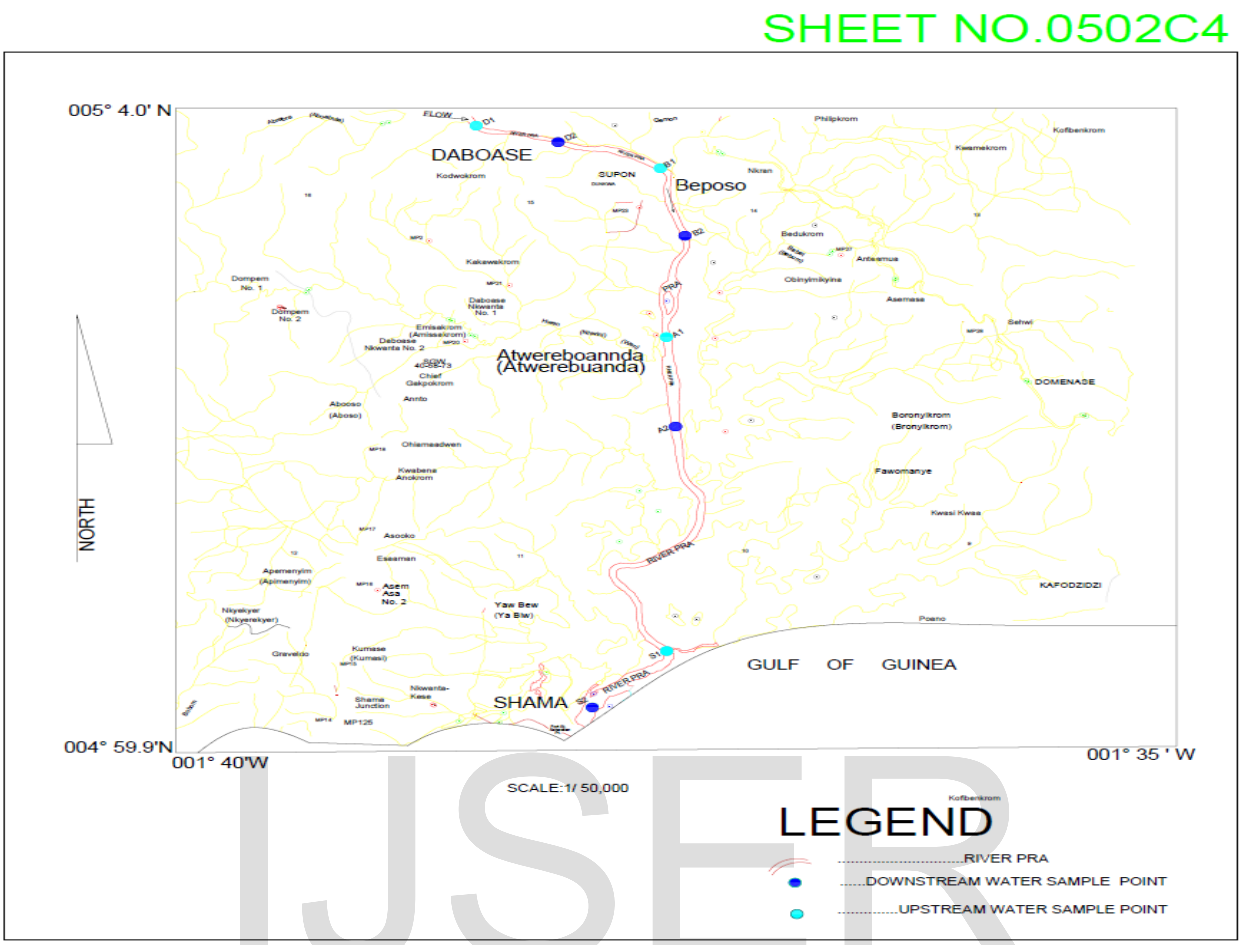

Figure1.Shows the selected upstream and downstream water sample point

2.2 Materials

Grabbed water samples were collected at the upstream and downstream of the four selected communities which depend on the river for their water supply, thus Daboase, Beposo, Atwereboanndaand Shama. The collected water samples were stored in a clean sterile 500ml glass bottle stored in a box at a temperature of 4 °C and transported for laboratory analysis at the GWCL. The samples collected were labeled as [S1 and S2], [D1 and D2], [B1 and B2] and [A1 and A2] for upstream and downstream of Shama, Daboase, Beposo and Atwereboannda respectively, as shown in F**ig. 1**.The pH, conductivity, color, temperature, turbidity, lead, mercury, total iron, total alkalinity, arsenic, nitrate, nitrite, salinity, lead, chromium, ammonia and phosphate of the samples were analyzed in accordance with test specification outlined in GWCL water manual. The results obtained were compared with the World Health Organization [6] standard for drinking water and the European Union [7] standard for quality of surface water intended for drinking. The physico-chemical parameters were analyzed in duplicates.

Field observations were carried out along the river bank to identify and ascertain the anthropogenic activities along the river and the impacts of these activities on the river. Furthermore, three persons were purposefully selected from each of the four communities along the river bank and interviewed on the processes involved in the various human activities they engage. Ten (10) indigenes from each community depending directly on the Pra River were also randomly selected and interviewed to ascertain their views and perceptions on the water use and the current state of river

3 RESULT AND DISCUSSION

3.1 Observation and interview

The field observations showed that, areas along the river bank for all selected towns are used by peasant farmers who do not apply fertilizer in their farming activities. It was also observed that, the river flows and meander through rocks from Beposo to Atwereboannda. Thus the topography of the surrounding areas was observed to be of higher elevation than that along the banks resulting in surface run-off entering the river during high precipitations. Further observations showed that, small scale and illegal mining activities are daily activities that take place in the river from Daboase through to Atwereboannda.

A total of 40 indigenes were interviewed, 75% responded to use the river for daily activities because of easy accessibility and 10% and 15% use groundwater and water from Ghana Water Company Limited (GWCL) respectively. Those who used the pipe born water were the indigenes around Daboase and Shama who are connected to GWCL distribution network.

The interview further revealed that, 60% of the people uses the river for cooking, bathing and washing, where as 50% drink the river water by either boiling or filtering. 95% of the interviewees confirmed a rapid change in colour [**fig.2**] since the invasion of illegal mining activities, and 25% complained of stomach upset and skin diseases upon the usage of the river water

Figure 2.shows the color of Pra River before and now. Source: WRC, 2015

3.2 Water analysis

The (average) of the water quality results were obtained and recorded alongside with WHO standard for drinking water and European Union raw water quality standard for potable water abstraction as shown in **Table 1**.

The mean values for temperature of samples collected were above the EU standard for both mandatory and guide limits. Although temperature has no health implications, it has significant effect on the rate reaction.

The mean values of pH for samples collected ranged from 6.5 to 7.The pH values are within the range of WHO and EU standard. A pH value lower than 6.5 can be considered acidic for human consumption and can cause acidosis, however, pH values greater than 8.5 are also considered alkaline for human consumption.

The average values for color for the all samples were above the WHO and EU standard for color. This can be attributed to the illegal mining operations and the infiltration of storm run-offs into the river during heavy down pour. This indicate strong objection of water from the river for human consumption.

The WHO permissible limit for turbidity of water is 5NTU.The average turbidity values for the samples ranged from 536 to 754NTU.These values are far above the WHO permissible limit. The existence of turbidity also affect it acceptability and it utility. But, the average conductivity values for samples were far below the guide limit of EU standard, although there is no limit for set by WHO.

The ammonia, phosphate, nitrate and nitrite concentration of samples were below the EU guide limit. The nitrate and nitrate values ranged from 2.3 to 4.21mg/l and 0.009 to 0.01mg/l respectively.

The chemical characteristic analysis of the samples indicated iron, lead, mercury, arsenic, copper, zinc and chromium. The values recorded for zinc, chromium and arsenic were below the permissible limits of WHO and EU standard for drinking water. The mean values for zinc, chromium and arsenic ranged from 0.02 to 0.04mg/l, 0.01 to 0.02mg/l and 0.002 to 0.003mg/l respectively. However, the continuous illegal mining in the river might increase their concentration. The average concentration values for copper, mercury and lead were within the range of the WHO and EU permissible limits for drinking water. The mean values for copper, mercury and lead ranged from 0.09 to 0.13mg/l, 0.01 to 0.03mg/l and 0.002 to 0.01mg/l. Though traces of these metals are sometimes needed by the body to satisfy it nutritious requirement, only minute quantities are required as higher doses lead to health hazard which are sometimes lethal. The mean concentration of mercury affirms the report by GWCL [4], which state that, widespread use of mercury in illegal mining for gold recovery has led to a situation where mercury poisoning is highly likely if use in the river for domestic purposes".

The average concentrations of chloride for samples collected were far below the permissible limits of WHO and EU. In addition to low salinity compared with WHO and EU standards, indicate no salt water intrusion. The WHO permissible limits for total iron are 0.3mg/however the average concentration for total iron for the samples ranged from 2.45 to 2.7mg/l. These values are far above the permitted. Although there is normally no health implication on persons consuming water with high level of iron, high concentration of iron in water lead to aesthetic problems.

Table 1: **Water quality parameters of collected samples.**

Parameters	**WHO guideline value**	**EU raw water quality standard**		**Results of Sampled Water**											
				Daboase			**Beposo**			**Atwereboannda**			**Shama**		
		I	**G**	D_1	D_2	**W**	B_1	B_2	**X**	A_1	A_2	**Y**	S_1	S_2	**Z**
Temperature (°C)		**22**	**25**	28.1	28.9	**28.5**	27.9	28.4	**28.2**	28.8	29	**28.9**	29.3	28.6	**28.95**
pH	**6.5- 8.5**	**6.5- 8.5**		6.54	6.45	**6.495**	6.59	6.63	**6.61**	6.63	6.64	**6.635**	6.61	6.95	**6.78**
Colour (PtCo)	**0-15**	**10**	**20**	97	94	**95.5**	227	128	**178**	120	153	**136.5**	142	98	**120**
Turbidity (FAU)	**5.0**			549	562	**555.5**	738	769	**754**	542	530	**536**	542	609	**575.5**
Conductivity (µs/cm)		**1000**		90	110	**100**	100	90	**95**	140	230	**185**	140	230	**185**
Salinity (mg/l)	**0-15**			0.03	0.05	**0.04**	0.03	0.04	**0.04**	0.04	0.07	**0.055**	0.07	0.1	**0.085**
Total Dissolved Solids	**1000**			50	60	**55**	55	50	**52.5**	60	110	**85**	100	135	**117.5**
Total Alkalinity (mg/l)				75	50	**62.5**	55	70	**62.5**	80	55	**67.5**	70	65	**67.5**
Total Iron (mg/l)	**0.3**			2.761	2.718	**2.7395**	2.682	3.026	**2.854**	2.664	2.474	**2.569**	2.503	2.329	**2.416**
Zinc (mg/l)	**3.0**	**0.5**	**3.0**	0.015	0.025	**0.02**	0.034	0.039	**0.037**	0.014	0.041	**0.0275**	0.006	0.019	**0.013**
Copper (mg/l)	**0.1**	**0.02**	**0.05**	0.114	0.105	**0.1095**	0.125	0.131	**0.128**	0.11	0.1	**0.105**	0.101	0.084	**0.093**
Chromium (mg/l)	**0.1**		**0.05**	0.017	0.024	**0.0205**	0.016	0.019	**0.018**	0.018	0.021	**0.0195**	0.028	0.018	**0.023**
Lead (mg/l)	**0.01**		**0.05**	0.019	0.015	**0.017**	0.026	0.029	**0.028**	0.012	0.014	**0.013**	0.022	0.028	**0.025**
Arsenic (mg/l)	**0.01**	**0.01**	**0.05**	0.003	0.002	**0.0025**	0.003	0.003	**0.003**	0.003	0.002	**0.0025**	0.002	0.003	**0.003**
Nitrate (mg/l)	**10.0**	**25.0**	**50**	2.5	3.6	**3.05**	5.3	3.1	**4.2**	3.8	3.2	**3.5**	2.4	2.2	**2.3**
Nitrite (mg/l)	**3.0**			0.002	0.016	**0.009**	0.011	0.006	**0.01**	0.015	0.012	**0.0135**	0.014	0.002	**0.008**
Ammonia (mg/l)	**2.5**			0.01	0.02	**0.015**	0.01	0.02	**0.02**	0.02	0.02	**0.02**	0.01	0.01	**0.01**
Chloride (mg/l)	**250**			0.20	0.21	**0.205**	0.2	0.2	**0.2**	0.18	0.16	**0.17**	0.25	0.40	**0.325**
Phosphate (mg/l)		**0.4**		0.25	0.24	**0.245**	0.21	0.15	**0.18**	0.15	0.25	**0.2**	0.12	0.31	**0.215**
Mercury (mg/l)	**0.001**	**0.0005**	**0.001**	0.006	0.008	**0.007**	0.004	0.006	**0.01**	0.001	0.002	**0.0015**	0.002	0.002	**0.002**

*EU raw water quality standard for category A1:potable water abstraction for simple physical treatment(filtration) and disinfection
*G: Mandatory limit I:Guide limit
*D1,D2 samples collected from Daboase upstream and downstream respectively and **W**as the mean
*B1,B2 samples collected from Beposo upstream and downstream respectively and **X** as the mean
*A1,A2 samples collected from Atwereboanndaupstream and downstream respectively and **Y** as the mean
*S1,S2 samples collected from Shama upstream and downstream respectively and **Z** as the mean

Source: Field data, 2016

4 CONCLUSION

From the study, it was revealed that the four (4) selected communities along the river have three main sources of water supply thus river water, groundwater and pipe water. However majority of the indigenes depend on the river due to it accessibility and reliable availability. The study also identified that, 50% of the indigenes from the selected communities use Pra River as their drinking watersource and 25% complained of stomach upset and skin diseases after use.

The laboratory analysis of theeight (8) samples collected from four(4) of selected communities showed that, out of the nineteen (19) water quality parameters analysed, twelve parameters thus;pH,conductivity,nitrate,nitrite,zinc,arsenic,ammonia,chromium,salinity,alkalinity,phosphate and chloride were within the permissible limit set by WHO and EU standards.However there were reasonable concentration of zinc, chromium and arsenic in the samples collected. All other physico-chemical parameters were above the permissible limits set by WHO and EU which pose high treat to consumers.

5 RECOMMENDATION

It recommended that Ghana Water Company Limited (GWCL) should widen their water supply coverage to meet the water need of the communities. It is therefore suggested that small scale miners and illegal miners should be stopped from carrying out their activities in the Pra River. Water users should also be on guard to report any physical changes in the river to the appropriate authorities in order to ensure the fitness of the river.

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REFERENCES

[1] UNESCO, (2006). UNESCO water portal newsletter no.161: Water-related diseases.

[2] MeybeckChapman D & Helmer R.eds (1989). Global Freshwater Quality: A First Assessment.Blockwell Reference, Oxford, U.K.

[3] Barai, S.R. and Kumar Satish (2013).Evaluation of The physico-chemical characteristics of river Varuna at Varanasi. Journal of Environmental Biology, Vol.34, 259-265.

[4] Ghana Water Company Limited, 2015.Retrieved from www.myjoyonline.com/news/2015/July-23rd/ghana-water-identifies-cancer-causing-chemicals-in-pra-river.php#sthash.vrAo2MCD.dpuf [Accessed Date: May, 2016].

ISSN 2229-5518

[5] Water Resource Commission, 2000.Retrived from www.wrc-gh.org [Accessed Date: November, 2015]

[6] WHO, (1993). Guidelines for drinking water quality. Publisher: WHO, Geneva, Switzerland

[7] European Communities [Quality of surface water intended for abstraction as drinking water] Regulation 1989. [S.I No 294 of 1989.5]