Comparative Studies of the Quality of Three Sources of Water Accessible to Bebor International Model Nursery/Primary School*

Abstract: *Some water quality parameters were assessed on water samples obtained from three main sources accessible to and used by Bebor Nursery/Primary School pupils. Results obtained were compared with international standards. Comparatively, water from the newly installed borehole at Bebor School has better quality than the other two waters (well and stream) examined*.

Introduction:

Potable water is an essential ingredient for good health and the socio-economic development of man (Udom et al, 2003), but it is lacking in many societies. The people of Bodo, where Bebor International Model Nursery/Primary School is located, derive water for domestic uses from stream, well and (rarely) from borehole. One major drawback of these sources of water relative to conventional public water supply is that while the latter is readily subjected to routine evaluation of key water parameters to determine suitability before pumping into circulation, others are not.

Both well and borehole waters are groundwater sources, while stream water is classified as surface water. The quality of each water category can be impaired due to exposure to contaminants from various sources especially from human activities. Hitherto, Bebor staff and pupils had depended solely on water from a well dug in the school premises. The school is non-residential; pupils come to learn and return to their homes daily. While at home, the pupils either drink well, borehole or stream waters.

In June 2009, a borehole was installed at the primary section of Bebor School. Funds for the borehole installation and 2-year operations costs were provided by Stepping Stones Nigeria (SSN). SSN is a British-based child's rights charity. With the borehole in place, the staff and pupils of Bebor School and villagers near the school presently secure their water supply from the borehole, which at least requires less energy to obtain, and at best is arguably of better quality.

A study was conducted to evaluate the qualities of stream water, Bebor well water and the newly established Bebor borehole water, and the results compared with international quality standards.

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DESCRIPTION OF WATER SOURCES

Stream water: Pockets of stream exist in Bodo City given its location in the cartographic Niger Delta that is characterized by copious surface waters. Many of the streams at Bodo are seasonal swampy streams formed by the accumulation of runoff during the rains. Ke-or stream water is an exceptional non-seasonal stream. It is located in a virgin forest called Kul Zorkpa. It is spring fed, and flows unidirectional downstream, meandering through the Zorkpa forest and links to the Bodo brackish water creek at Te Kpoo Kuru. During floodtide, salt water from Bodo Creek pushes considerably into Ke-or stream until a point of slack where the stream velocity counteracts the saline water inflow. From the head waters downstream, Ke-or stream is partitioned for community usages: near the headwaters is meant for drinking and cooking, followed by the bathing section for women, and the men section. Ke-or stream was chosen for the study because of its popularity and non-seasonality.

Bebor well water: The school has a dugout well of about 25m deep situated at the rear of the Bebor primary school premises. The well mouth is covered with a lid, which is removed and replaced during and after drawing (fetching) from it.

Bebor borehole water: The borehole was installed in June 2009 at the Bebor primary school section. The borehole supplies water for the staff and pupils of the school, and also villagers who come to fetch from it free of charge from community taps located on the exterior side of the wall demarcating the school's property.

WATER QUALITY PARAMETERS: A total of eight chemical and five microbiological parameters necessary for determining water quality were assessed on each water source. The parameters and introductory notes on them are provided below.

- **Conductivity or Specific Conductance:** is a measure of the ability of water to conduct an electric current. It is sensitive to variations in dissolved solids, mostly mineral salts. In other words, this parameter gives an idea of the salt concentration in water.

- **pH:** is a measure of the acid balance of a solution – that is, the degree of acidity or alkalinity of a medium. The pH scale runs from O to 14 (1 – 6 is acidic; 7 neutral; and above 7 to 14 alkaline).

- **Dissolved Oxygen (DO):** is simply the amount of oxygen dissolved in water. Oxygen is essential to most forms of aquatic life, including those organisms responsible for the self-purification processes in natural waters. DO can be express in terms of percentage saturation, and levels less than 80% saturation in drinking water can usually be detected by consumers as a result of poor odour and taste.

- **Nitrate:** The nitrate ion (NO_3) is the common form of combined nitrogen found in natural, waters. Natural concentration of nitrate seldom exceed 0.1mg/l (mg/l = minigram per liter), but may be enhanced by municipal and industrial waste waters, including leachates from waste disposal sites and sanitary landfills. In rural and suburban areas, the use of inorganic nitrate fertilizers can be a significant source.

- **Biochemical Oxygen Demand (BOD):** is an approximate measure of the amount of biochemical degradable organic matter present in a water sample. It is defined as the amount of oxygen required by microorganisms to degrade organic substances present in water over a period of 5 days at a temperature of 20°C.

- **Chloride:** Most chlorine occurs as chloride in solution. High concentrations of chloride can make waters unpalatable, and therefore, unfit for drinking. It is one of the important inorganic anions in water and waste water.

- **Sulphate (SO_4^2):** It is the stable, oxidized form of sulphure that can be used as an oxygen source by bacteria which convert it to hydrogen sulphide.

- **Hardness:** Originally, water hardness was understood to be a measure of the capacity of water to precipitate soap (APHA, 1998). Soap is precipitated chiefly by the calcium and magnesium ions present.

- **Coliform Bacteria:** A group of gram-negative rod-shaped bacteria that are found in vertebrate gastrointestinal tract (digestive system); their presence in water is an indication of faecal pollution. The bacteria obtain their energy by aerobic respiration or fermentation. Well known coliform bacteria include *Escherichia coli, Salmonella, etc.*

SAMPLING AND LABORATORY ANALYSIS

Water samples were collected from the three sources described earlier following standard procedures (APHA, 1998). The samples were transported in ice-chest to the University of Port Harcourt where they were analyzed using standard methods.

RESULTS

Table 1 shows results of the chemical parameters examined, while microbiological data are presented in table 2. The results are compared with permissible limits of the World Health Organization (WHO, 1993) and the more stringent standards of the European Union (EU, 1998).

Table 1. Results of chemical parameters of three drinking water sources accessible to Bebor Nursery/Primary School at Bodo, Rivers State, Nigeria.

Parameter	**Well Water**	**Stream Water**	**Borehole Water**	**WHO 1993**	**EU 1998**
pH	6.39	7.01	7.34	6.5 – 9.5	Not Mentioned
Hardness (mg/l)	4.80	4.80	2.40	No guideline	Not Mentioned
Sulphate (mg/l)	0.69	13.78	0.69	500	250
Nitrate (mg/l)	3.62	5.47	3.53	50	50
DO (mg/L)	5.60	6.00	4.00	No guideline	Not Mentioned
BOD (mg/l)	20.00	8.00	12.00	No guideline	Not Mentioned
Conductivity (µS/cm)	18.0	16.00	16.00	250	250
Chloride	13.60	18.40	11.20	250	250

Table 2. Microbiological quality of three drinking water sources accessible to Bebor School

Parameter	**Well Water**	**Stream Water**	**Borehole Water**	**WHO 1993**	**EU 1998**
Total Heterotrophic count (cfu/ml)	1.13×10^{4}	2.05×10^{4}	6.4×10^{3}	NM	NM
Faecal coliform (cfu/ml)	15/100 ml	25/100 ml	Nil	NM	0in 100ml
***Salmonela* (cfu/ml)**	Nil	Nil	Nil	NM	NM
***Vibrio* (cfu/ml)**	Nil	Nil	Nil	NM	NM
***E. Coli* (cfu/ml)**	Nil	4.0×10^{1}	Nil	NM	0 in 250ml

NM = Not Mentioned; cfu= colony-forming-unit

DISCUSSION

Some water associated diseases are caused by chemicals or lack of them (Okafor, 1985). pH values recorded (table 1) show well water to be slightly acidic and below the lower permissible limit recommended by WHO. pH values of both stream and borehole waters were slightly alkaline, and within WHO's limit for drinking water. I presume that low pH of the well water is likely caused by organic contamination. Udom *et al*, (2002) recorded a similar low pH, though slightly higher (6.9) than the value for well water in this study, for borehole water taken from Bodo. They attributed the low pH to the abundance of organic matter in the overlying soils. Decomposition of organic matter leads to a decrease in pH (acidity). The levels of organic contamination in the soil would vary, ideally, with depth of the soil strata – that is, decreasing from the top. Thus, I speculate that the low pH values measured by the above authors and in the well water sample of this study are indicative of the low depth of their water aquifers. Apart from natural leachates, additional organic input can be introduced into the well from atmospheric droplets and human contamination during fetching at which time the well is uncovered. Based on the WHO limits for pH, both the stream and Bebor borehole waters are more suitable for drinking than Bebor well water. It must be stressed that, though, Ke-or stream is also prone to similar (and even more) organic contamination as the well water discussed above, the stream water is steadily buffered by constant flow velocity and water renewal or exchange while in contrast, the well water is static. Acidic waters favour the growth of iron bacteria which cause incrustation of pipes.

Total hardness data (table 1) indicate that the three waters are soft and suitable for domestic uses. The waters will foam easily with soap. Comparatively, the Bebor borehole water sample had the lowest value (2.40 mg/l), and will produce lather with soap easier than the well and stream waters. The direct effect of hardness on human health is yet to be proven scientifically (Sharma *et al*, 2004). The levels of sulphate and nitrate recorded are also very low compared to WHO and EU limits of (500, 250 mg/l) and 50 mg/l respectively. This means that the sulphate and nitrate levels of the three waters are not injurious to health. High sulphate concentration causes gastrointestinal irritation. Excess nitrate in drinking water causes infantile methaemoglobinaemia, which acts on hemoglobin in children, leading to poor oxygen uptake at the cellular level. Research conducted by British Nutrition Foundation and Cancer Research Campaign in UK has shown the direct relationship between a high incidence of stomach cancer and the prolonged intake of nitrate rich drinking water (Sharma *et al*, 2004).

Chloride values measured are quite lower than the WHO/EU limit of 250 mg/l; chloride of the stream water was relatively higher than for the well and borehole waters. This is not unconnected with salt water intrusion from Bodo Creek into the stream basin. Concentrations of chloride above 250mg/l make drinking water impalatable by imparting salty taste, and may harm metallic pipes.

The borehole water had the least DO concentration, which is expected due to its enclosed nature. Sources of oxygen in water include the atmosphere, as by-product of photosynthesis and through hydro-mechanical input (that is, surface agitation). According to UNESCO/WHO/UNEP (1992), DO is of much more limited use as an indicator of pollution in groundwater, and is not useful for evaluating the use of groundwater for normal purposes. Conductivity values of the waters were far lower than WHO/EU limits, making the waters suitable for domestic uses, including for human consumption.

Results of the heterotrophic bacterial count (Table 2) show that the Bebor borehole water sample had the lowest bacterial load. This is simply a measure of the number of live bacteria present in water, and does not necessarily indicate health threats. Faecal coliform bacteria were detected in both well and stream waters, but were absent in the borehole sample. According to the EU standards (Table 2), water for drinking should have zero faecal coliform bacterial count in 100ml of the water. There were 18 and 23 faecal coliform per 100ml of the well and stream waters respectively. Since a section of Ke-or stream investigated is used for bathing and washing, it is most likely that faecal contamination arising from both human activities may have spread to the drinking section, hence, the presence of the faecal coliforms. Two possible reasons may account for the presence of faecal coliforms in Bebor well water: 1) contamination during fetching, and 2) leachates. Even though percolating waters lose their bacterial content as percolation progresses through the soil (natural purification), instances have been reported, where bacterial pollution of ground water has occurred (Narayan and Rao, 1981). In sum, judging from the standpoint of faecal coliform contamination, the stream and well waters are unsuitable for drinking.

Salmonella and *Vibrio* species were not detected in any of the water samples. *Salmonella* and *Vibrio* are causative pathogens of typhoid fever and vibrio cholera respectively. None of the waters has the potential of transmitting above waterborne diseases.

E. coli was detected (4.0×10^{1} cfu/ml) in the stream water sample only. *E. coli* is normally a harmless commensal in the alimentary canal of man and other animals. However some sero-types frequently cause gastroenteritis characterized by severe diarrhoea with mucus or blood and with dehydration but usually without fever. Children, especially the newborn, are usually affected but increasing cases of adult diarrhoea caused by *E. coli* are also being noted (Okafor, 1985). Therefore, the presence of *E. coli* in the stream water makes it potential health risk to its consumers.

CONCLUSIONS

On the basis of all chemical parameters examined the three water sources are suitable, at least at different levels as at the time of investigation, for domestic uses and drinking. However, the low pH recorded for Bebor well water falls outside WHO permissible limit, and raises serious health concern.

Microbiologically, Bebor borehole water leads in comparative quality. Traces of faecal coliforms in both well and stream waters assessed imply that consumers of both waters are vulnerable to the risk of infection. The risk of infection is further enhanced by the presence of *E. coli* in the stream water sample. From the standpoint of both chemical and microbiological parameters examined the quality of the waters for drinking is in the order: Bebor borehole > Bebor well > Ke-or stream.

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