19th WEDC Conference ACCRA, Ghana 1993

WATER, SANITATION, ENVIRONMENT and DEVELOPMENT

Status of groundwater quality in Ghana

J C Adzaku

Abstract

Groundwater quality is generally good throughout Ghana though acidic (pH 3.5 to 6.5) in some parts of the country. This is a reflection of very low level of contamination by human activity. However during the 1980's high concentrations of nitrate had been reported in some parts of the upper regions. It is believed that the changes in agricultural practices could be the source of high nitrate level. One consequence of this is that, high iron concentrations in excess of 0.30 mg/l, the WHO recommended guideline for drinking water quality, is not uncommon. Some boreholes have also been abandoned, especially along the coast because of high concentrations of chloride and total dissolved solids. The high chloride concentration is thought to be due to sea water intrusion into the coastal aquifers. Thus monitoring of aquifers in the country should be seriously undertaken so that changes in groundwater quality as a result of agricultural practices, anthropogenic activities and other developments could be quickly observed.

Introduction

The threat to groundwater quality in Ghana is not widespread. But in view of the importance of groundwater as the only available source of relatively inexpensive and untreated potable water over most parts of the country, it is very important that the aquifers are carefully managed. It is, therefore, important to undertake routine monitoring of the aquifers to establish baseline data against which changes in quality with time can be observed.

Data generated under the following groundwater exploration programmes in the country is used to assess problems associated with groundwater use:- Canadian International Development Agency (CIDA) in the Upper regions, Prakla Seismos 3000 Well Project in Southern and Central Ghana, the Catholic Secretariat projects in some Catholic dioceses, the Volta Regional Agricultural Development (VORADEP), the Presbyterian Churches, the Ghana Water and Sewerage Corporation (GWSC), the World Vision International (WVI), and the Water Resources Research Institute (WRRI) research programme in the Accra Plains.

Country-wide groundwater quality

Groundwater constitutes an important source of relatively inexpensive water supply for domestic, industrial and agricultural purposes. Unfortunately certain chemical substances notably iron, manganese, chloride and nitrate are sometimes present in objectionable concentrations. The parameters used in the problem identification are pH, nitrate, fluoride, chloride, total hardness and iron. These are shown in Table 1.

PH values

Groundwater in Ghana is generally acidic and corrosive. The pH values mostly range from 3.5 to 6.5. Out of 272 Prakla Seismos drilled boreholes in Ashanti, Volta, Brong-Ahafo and Western regions, 118 boreholes have pH values ranging from 3.93 to 6.49 (Adzaku, 1989). In the Accra Plains, 68.5% of 156 boreholes monitored monthly from 1988 to 1991 have pH values below 6.5 and 7.8% of WVI drilled boreholes also have pH values below 6.5.

The CIDA 2500 Well Drilling Programme in the Upper regions recorded pH values which ranged from 5.40 to 9.3. About 32% of the samples analyzed had pH values below 6.5. pH values below 6.5 were also reported in other drilling programmes carried out in the country by such organisations as the E.P Church Ghana, VORADEP and the Catholic Secretariat.

Nitrate

Groundwater nitrate concentrations in Ghana are generally low and reflect both limited development of intensive agriculture and the considerable separation (100m) between boreholes and village pit latrines. However rising concentrations of nitrate have been recorded under some of the borehole drilling programmes in the country. In 1980 high concentrations of nitrate were reported in some CIDA boreholes in the Upper regions of Ghana (Akiti, 1982). In all the samples analyzed, nitrate concentration ranged from 0.0 to 74.0 mg/l.

High nitrate concentrations were also recorded in some boreholes drilled under the Catholic dioceses drilling programmes. In the Tamale diocese the concentration was 25.0 mg/l at Jama and 22.5 mg/l at Chorobang. At Dodiyiri in the Wa diocese 46.0 mg/l nitrate was recorded. At Abomosarefo in the Accra diocese the concentration was 32.0 mg/l.

High nitrate concentration of 38.0 mg/l was also reported at Sovie, in the Kpandu district of the Volta region under the Evangelical Presbyterian Church Borehole Drilling Programme. However, under other borehole drilling programmes low nitrate concentrations were reported.

Fluoride

In all the drilling programmes, fluoride was determined only for the Prakla Seismos and CIDA programmes. A detailed study of fluoride content in well-waters were carried out by the Institute of Aquatic Biology (1978). Fluoride concentration in the CIDA Project area ranged from 0.11 to 5.0 mg/l; and that in the Prakla Seismos project area ranged from 0.0 to 40.0 mg/l.

Chloride

High chloride concentration is due to the presence of evaporite or connate water in the marine sediments. This may be the cause of high salinity of groundwater under the CIDA programme in the area around Tamale in the Northern region. Salt water intrusion into the coastal aquifers results in high salinity in southern Ghana. In the Accra Plains chloride concentrations range from 16.0 mg/l at Abokobi, near the foothills of the Akwapim Range to 2640.0 mg/l at Magnus farms in the centre of the Plains and 7000.0 mg/l at Tema, on the coast. In all the other projects chloride concentrations were also high along the coast.

Total hardness

Results of chemical analyses of borehole samples indicate high total hardness values in formations rich in calcium and magnesium compounds. Under the Prakla Seismos 3000 Well Drilling Programme, the main problem of the supplies is reflected by hardness which sometimes exceeded the WHO maximum acceptable level of 500.0 mg/l.

The hardest waters originate from wells drilled in the Togo Series, where the shales contain chlorides, sulphates and bicarbonates of calcium and magnesium. Soft waters were found in granitic formations where total hardness values were less than 50.0 mg/l $CaCO_3$. In the Accra Plains, soft to moderately hard waters were recorded at the foothills of the Akwapim Range and the hardest waters were reported along the coast.

Under the World Vision International Drilling Programme hardness ranged from 8.0 to 7700.0 mg/l. The hardest sources were located along the coast of Guinea. The hardness of all boreholes drilled under the Presbyterian Church and Catholic dioceses drilling programmes were below 500.0 mg/l.

Iron

Excess iron concentration in water supplies are mostly found in waters that come from granitic formations, phyllites and sandstones of the Birrimain and Tarkwain formations, the Voltaian upper sandstones, the sand and gravel of the Tertiary Sediments, quartzite, quartz and schist of the Togo Series.

Under the CIDA drilling programme iron concentrations ranged from 0.0 to 2.50 mg/l. Under the Prakla Seismos 3000 Well Programme high iron concentrations were recorded in the Western region ranging from 0.0 to 21.5 mg/l. at Muoho.

In the Accra Plains out of 79 borehole samples analyzed from 1988 to 1991 about 25% had excess iron concentrations. The highest concentration of 39.7 mg/l was recorded for borehole AP 195 at Ablekuma. For the Catholic Secretariat borehole drilling programme, iron concentrations ranged from 0.0 to 5.5 mg/l. The highest value of 5.5 mg/l was recorded at Jolliyiri in the Wa diocese.

Under the E.P. Church drilling programme the highest iron concentration of 2.5 mg/l was recorded at Klefe Achiatime and for WVI, the highest iron concentration was 112.0 mg/l in Zongo borehole at Ho Dome.

Discussion

High iron concentrations in boreholes in phyllite, granite and sandstone of the Tarkwaian and Birrimain are due to the presence of hematite, magnetite and iron carbonate bands in the units. The tertiary sands of the sedimentary basins of the Western and Volta regions are limonitic so excess iron concentrations in water from these deposits should be expected. The Upper Voltaian sandstone is made up of massive ferruginous sandstone so the unit always yields water of high iron concentrations.

The rising nitrate concentrations in borehole is attributed to changes in agricultural practices. This is the result of the change from shifting subsistence agriculture to a more settled and increasingly intensive crop production. Concern has therefore been expressed that these changes and the introduction of on-site sanitation, could result in increased leaching losses of nitrogen and cause a build-up of nitrate in the shallow groundwater reservoirs. High nitrate concentrations in some boreholes might also be due to nitrate deposits in the geologic formations.

Another problem of borehole supplies is reflected by hardness which sometimes exceed the maximum WHO maximum acceptable limit of 500.0 mg/l. Boreholes drilled in the Togo Series are very hard. This is caused by deposits of calcium and magnesium bicarbonates, sulphates and chlorides in the shales.

High levels of hardness and chloride are also found along the coast of gulf of Guinea. This might be due to sea water intrusion into the coastal aquifers.

Conclusion

The dissolution of iron compounds in the geologic formations, pump parts and other materials made of iron used in development of boreholes is possible because of low pH values. This is a serious water quality problem in Ghana and is one reason why some rural and urban water-supply boreholes have been rejected.

When iron is present in excessive amounts consumers complain about staining effects on laundry, cooking uten-

sils, plumbing fixtures and bitter or stringent taste. It is also expressed that when borehole water with high iron concentration is used in cooking starchy food stuffs, eg. plantain, cassava, maize etc it imparts abnormal colour to these food items. This makes the cooked foodstuffs have unaesthetic characteristics.

High nitrate concentration in water can be harmful and can cause methaemoglobinaemia, especially in infants. Nitrate also produces carcinogenic nitrosamines which cause cancer. Thus on-site sanitation and the more settled and increasingly intensive land use should be carefully planned and monitored so that there would be minimal nitrogen losses reaching the groundwater reservoirs.

Consumers of borehole supplies with high salinity complain about hardness and often abandon otherwise bacteriologically safe water supply.

It is unfortunate that the bacteriological quality of all boreholes drilled under various drilling programmes were not determined except in the Accra Plains. It is recommended, therefore, that bacteriological examination of boreholes should be encouraged.

References

1. Adzaku, J.C., (1989). A Study of the Effect of Groundwater Quality on Pump Materials in the Tropical Rain Forest Zone of Ghana. Water Resources Research Institute, (CSIR), Accra.
2. Akiti, T.T. (1982). Nitrate Levels in some Granitic Aquifers from Ghana. Paper presented at International Symposium IAH, Prague Czechoslovakia. "Impact of Agricultural Activities on Groundwater".
3. Antwi, L.A.K., (1978). Natural Fluoride Levels in Boreholes in Northern Ghana. Institute of Aquatic Biology (CSIR), Accra.
4. WHO (1984). Guidelines for Drinking Water Quality, Vol. I Recommendations WHO Publication. Geneva.

Table 1. Parameters used in problem identification in boreholes
(Results are expressed in mg/l except pH)

Parameter	*Catholic Dioceses*				*Cida*		*Accra Plains*		*Prakla Seismos*		*World Vision Interational*		*E.P. Church*		*Presby Church*		*Voradep*	
	Keta/Ho	Tamale	Wa	Accra	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Ph	5.30 - 7.8	5.53 - 8.34	6.09 - 7.69	6.12 - 7.29	5.5	9.3	0.04	7.6	3.93	8.2	4.3	8.2	5.53	7.30	5.03	6.82	4.9	8.5
Iron	0.0 - 1.2	0.02 - 1.0	0.0 - 5.5	0.0 - 0.89	0.0	2.5	0.02	39.7	0.0	21.5	0.0	51.8	0.05	2.5	0.0	3.0	0.0	34.1
Chloride	0.0 - 60.25	0.15 - 70.0	1.0 - 70.0	0.0 - 77.0	0.25	30.0	16.0	8750	4.0	588	6.0	8750	1.5	124	10.0	78.0	5.0	455.6
Nitrate	0.0 - 6.1	0.0 - 25.0	0.0 - 46.0	0.0 - 32.0	0.0	74.0	0.0	3.26	0.0	19.5	0.0	14.7	0.0	38.0	0.0	6.0	0.0	19.5
Fluoride	-	-	-	-	0.11	5.5	-	-	0.0	40.0	-	-	-	-	-	-	-	-
Hardness	3.0 - 52.0	-	-	-	55.0	364.0	36.0	3230	1.7	950	8.0	7700	30.0	240	4.5	235.8	7.0	777.86