

INDUSTRIAL POLLUTION STUDIES IN BENUE STATE: A STUDY OF SUBSURFACE WATER POLLUTION BY A CEMENT FACTORY

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Abstract

Though there are several scenarios for industrial pollution control the best option so far in Nigeria is the regulatory approach put in place by the establishment of FEPA. With the ultimate objective of assessing the extent of compliance of BCC to effluent limitation guidelines of FEPA, we undertook a study of the effect of BCC waste discharges on the quality of sub-surface water. Water pollution parameters including pH, total hardness, total dissolved solids, iron, aluminum, sulphate, silicate and calcium ions were determined by UV-visible spectrophotometer and complexometric methods. The results revealed that the quality parameters of sub-surface water in the area within the range stipulated by WHO. These findings imply that the effluents of BCC have insignificant impact on the quality of the sub-surface water. The results, which are unusual of industrial areas in Nigeria, may be attributed to effective method(s) of pollution abatement employed by BCC.

Introduction

The term sub-surface water is used here in reference to water held in the zone of saturation, and may occur in any rock type be it igneous, sedimentary or metamorphic and form a reservoir. Its origin can be explained in terms of the hydrological cycle, which is the continuous circulation of moisture and water on earth. Sub-surface water occurs within the earth at depths below the water table and originates due to seepage from precipitation that goes down below the zone of capillary water.

Generally, water is said to be polluted when it contains substances that prevent or prohibit its normal use. Sub-surface water is a very important reservoir today, as many towns, villages, farm and industries in the Middle Belt and Northern States of Nigeria rely for water supply from wells and bore-holes. Underground water recharge occurs through surface or sub-surface sources, and pollution is possible through either source. Subsurface water is usually characterized by low contents of organic substances, and appreciable concentrations of mineral salts and sometimes dissolved gases such as hydrogen sulphide and carbon (iv) oxide. There is a direct relationship between the bedding depth of subsurface water and its degree of mineralization.

Industrial Effluent as Pollutants

In a manufacturing industry, raw materials are processed and converted into products that are needed by the community. Associated with finished products are wastes from the raw materials and from energy use. The wastes are released into our environment as pollutants which find their way into sub-surface water through seepage (Odieta, 1996).

Benue Cement Company (BCC) Pic. produces Portland Cement. Portland cement is a heterogeneous substance made up of several fine-grained minerals, which are formed during the clinking process. The different basic components are lime (CaO), Silica (SiO₂) alumina (Al₂O₃), iron (III) oxide (Fe₂O₃), sulphate (SO₄²⁻) from gypsum. In some cases, minor components such as magnesia (MgO), potassium oxide (K₂O), sodium oxide (Na₂O) are also added to obtain the desired quality of cement.

During (he quarrying process, mixing of the raw materials, grinding of the raw materials, heating the raw materials in the lime kiln and blending of the clinker with gypsum, large quantity of dust is released into the environment. Thus dust may be raw meal or even cement and other particulate including gases which form the effluent of the cement industry then discharge into streams, rivers, ponds and eventually subsurface water (Stochi, 1990).

It is expected that the discharge of dust and particulates into the atmosphere, land, surface water and eventually into subsurface water through diffusion and perhaps massively through pecculation will increase substantially the levels of these ions in sub-surface water and therefore make these sub-surface water sources within the 2km radius of the BCC factory above World Health Organization (WHO)

acceptable limits for potable water and would be unacceptable for normal use (Nsi and Shalluku, 2002).

Experimental

Sampling and Sample Preservation

Sampling for analysis was carried out in June, 2002. Samples were collected from land-wells within the settlement area near the Benue Cement Company (BCC) Pic., Gboko, only as there was no existing bore-hole within the sampling area. Samples were collected from ten selected wells of varying distances from the cement factory. In each case, five sub-samples were obtained at varying depths. Representative sample was then obtained from the mixture of the sub samples. Collection of sample was by bailing in clean dried 1 litre plastic bottles with thirty fitted covers. Samples were preserved in a refrigerator at a temperature of 4°C to avoid deterioration due to microbial activities.

Colour taste and odour were noted in the field at the time of collection of samples.

Location of Study Area

Samples were collected from the study areas indicated in Figure 1.

- 1) The detail of the study locations showing their respective distances from the BCC factory is given in Table 1.

Analysis

Determination of Turbidity

The turbidity of the water samples was determined using HACK DR/2000 spectrophotometer by absorptiometric method. The range being 0 to 150 Fonnazin Turbidity Unit (FTU). The operation of the spectrophotometer was in accordance with the operation manual.

Determination of pH

pH of the samples was determined using the pH meter.

Total Dissolved Solids (TDS)

The total dissolved solid measurement was done using conductivity/TDS meter. The TDS was recorded in g/L.

Determination of Total Hardness

Determination of total hardness was carried out titrimetrically using digital titrator as the main instrument. EDTA Titration Cartridge was used corresponding to the expected hardness level. The number of digits (from tables) required was recorded.

Analysis for Calcium and Magnesium

This was calculated from the result of the titration for the determination of total hardness earlier discussed. The calculation is as follows:

Mg/L of calcium = mg/L total hardness as $\text{CaCO}_3 \times 0.400$.

Mg/L of magnesium = mg/L total hardness - mg/ as CaCO_3 .

The value 0.400 is a digit multiplier for the 25ml of the sample used.

Determination of Sulphate

The determination of sulphate in the samples was by spectrophotometric method using the 'sulfacer 4' method. The stored programme for sulphate was entered and the wavelength dialed to 450nm. Untreated sample was used as control in each case. 25cm³ of the samples was taken in the sample cell of the spectrophotometer and treated in each case with a 'sulfacer 4' sulphate 'pillow'. This was stirred properly to homogenize and after five minutes of reaction, it was placed in the cell holder and light shield closed. The result was then recorded for the display unit in mg/L.

Analysis for Silicate

Analysis for silicate was carried out using spectrophotometric method. Silicomolyhdate method was employed in the determination. The stored programme number was for high range silica -(SiO₂)

was entered. Wavelength of 45nm was used. A sample cell was filled with 25cm³ of the sample and one molybdate reagent powder pillow was added. It was swirled to mix. Content of one acid reagent power pillow for high range silica was (SiO₂) was entered. Wavelength of 452nm was used. A : sample cell was filled with 25cm³ of the sample and one molybdate reagent powder pillow was added, ft was swirled to mix. Content of one acid reagent power pillow for high range silica was added. A ten minutes reaction period was given. The sample was capped and placed in the cell holder with light shield closed. After about 2 minutes, content of one citric acid powder pillow was added to the sample" cell. It was swirled to mix. Untreated sample was used as control. The prepared sample was finally placed in the cell holder and the light shield closed. The result was then read from the display unit in mg/L(Vogel, 1978).

Determination of Iron

Determination of iron was done spectrophotometrically for all the samples. 'Ferrover' method was used.

The stored programme number for iron was entered and the wavelength dialed to 510nm. A sample cell was filled with 25ml of the sample and the content of one 'ferrover' iron reagent powder pillow was added. A three minute reaction was allowed. It was then placed in the cell holder and 'read' key pressed. The result was displayed in mg/L and was similarly recorded.

Results and Discussion

Results

The results of the analysis described in the previous sections are presented in Tables 2 and 3. These results are averages of five values each.

Discussion of Results

All the samples analyzed had clear appearances. This is evident to their turbidity values which range from 6.00 to 24.00FTU. These low values could be attributed to the filtration the water undergoes in the course of percolation through the different soil layers. They were colourless due to the negligible content of iron and other colour causing impurities. The salty taste peculiar to these samples could be due to the presence of dissolved salts and carbon (IV) oxide. The possible filtration processes underground water undergoes have probably prevented waste water from reaching it and therefore render it colourless.

Total dissolved solids (TDS range is found to be very low with sample No. 6 having the highest value of 0.18g/L and sample No. 3 having the least value of 0.10g/L. The results of the pH determination reveals that all the samples range from weakly acidic, neutral to slightly alkaline.

Total hardness in the samples obtained from the study area is moderate as shown in Table 2. This may be caused by the presence of carbonates, hydrogen carbonate and sulphate of calcium and magnesium. The values obtained reflect the variation in the direction in which the pollutants are being carried away. Sulphate values were also moderate with sample No. 8 having the highest value of 33.mg/L and sample No. 4 having the lowest value of 15.00mg/L. These values could be attributed to pollution as a result of the utilization of gypsum in the cement production.

There is no regular gradation of the values of the parameters investigated as a consequence of their distance from the factory. Therefore, one cannot reliably assert that distance from the factory affected the values obtained for the different parameters.

Results of analysis for the various parameters in the different sampling points indicate that the level of pollution is not significant. However, parameter such as turbidity has values close to WHO prescribed maximum limits.

Table 1: Study Locations and Their Distances from BCC Pic. Factory

Sample	Location Name	Distance
1.	Averts compound	400m
2.	Terhemba's compound	500m
3.	Tior Gbeehe's compound	610m
4.	Etina Hotel	700m

5.	RCM Tse Kucha	800m
6.	Nyam	950m
7.	Ayev	1020m
8.	Atighil	1500m
9.	Or	2000m
10.	BCC Nursery School	

Tab 1 e 2: Results of Physical Parameters

Sample	Turbidity (FTU)	T.D.S. (g/l)	Taste	Odour	Colour
1.	6.00	0.15	Salty	Odourless	Colourless
2.	16.00	0.13	Salty	Odourless	Colourless
3.	24.00	0.10	Salty	Odourless	Colourless
4.	9.00	0.12	Salty	Odourless	Colourless
5.	22.00	0.15	Salty	Odourless	Colourless
6.	20.00	0.15	Salty	Odourless	Colourless
7.	24.00	0.12	Salty	Odourless	Colourless
8.	10.00	0.11	Salty	Odourless	Colourless
9.	10.00	0.14	Salty	Odourless	Colourless
10.	8.00	0.16	Salty	Odourless	Colourless

Table 3: Results of Chemical Parameters (nig/L)

Sample	Total Hardness	Calcium	Magnesium	Silica	Sulphate	Iron	pH
1.	15.00	10.00	5.00	20.20	16.00	0.09	7.20
2.	16.70	12.50	4.20	22.10	25.00	0.00	7.00
3.	17.60	11.50	6.10	27.30	15.00	0.00	7.10
4.	17.50	12.50	5.00	22.00	20.00	0.02	7.20
5.	19.70	13.40	6.30	25.00	30.00	0.01	6.90
6.	17.40	13.70	3.70	26.00	32.00	0.10	6.80
7.	16.90	12.80	4.10	24.60	18.00	0.10	7.00
8.	17.60	12.00	5.60	23.00	33.50	0.06	6.80
9.	16.80	13.50	3.30	24.20	18.50	0.01	6.90
10.	18.60	13.30	5.30	25.50	31.00	0.05	7.00

It is also reasonable to say that higher pollution levels could be obtained in the rainy season (months with high intensity of rainfall in Benue; July, August and September) than the result of the present research. This is because the pollutants would be carried by run-off water direct into wells, especially those not properly covered. Also since the water level would be quite high, the dust maybe dissolved into the water without undergoing the natural filtration by the soil layers.

Conclusion

Analysis of both physical and chemical quality parameters of water were carried out with subsurface (well) water obtained from locations with varied distances from BCC Plc. factory. Results obtained indicate that the water quality fall within the range of World Health Organization (WHO) limits for potable water. Residents of the area are therefore encouraged to continue to use water from this source without fear of contamination provided they take appropriate hygiene measures by conveying the wells properly and avoiding indiscriminate waste disposal near the wells.

Recommendations

- 1) As a matter of urgency, the Benue Cement Company (BCC) Plc should install efficient stack purification devices to trap dust to avoid air, land and surface water pollution.
- 2) Residents of the study area should always cover their wells with locks and keys to avoid direct

contamination of their well water with the dust pollutants with its inherent chemical constituents.

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