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THE IMPACT OF URBANIZATION AND PROTECTION OF WATER RESOURCES, OWERRI, NIGERIA

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Short-term surface water and groundwater pollution surveys of the Owerri urban area and environs were conducted to establish current levels of pollution. An attempt has been made to show the relationships between pollution levels, population density, and industrial and agricultural activities. The spatial distribution of pollutants due to a poor land use system and human activities were investigated, thus emphasizing integrated planned development as a preventive measure for arresting pollution levels in fast growing urban centers. The total groundwater stored in the area amounts to 7.87 x 10^9 m^3. Twenty five percent of this is released as base flow into the adjacent rivers (Otamiri and Nworie). The annual groundwater recharge is 3.4 x 10^9 m^3. The enormous volume of groundwater stored and the comparatively low cost of development makes groundwater a better alternative supply source to the area.

INTRODUCTION

Urbanization can be defined as change from rural to urban character. On the 3rd of February, 1976, Imo state was created with Owerri as the capital. More than 10,000 civil servants of the Imo State administration moved into town increasing the population greatly.

Owerri lies at the junction of two rivers; the Nworie River coming from the north and the Otamiri river flowing towards the southwest. Both rivers lie in valleys with moderate slopes. The terrain to the west is completely flat. In the east, small rolling hills run from the north to the south. It has a subequatorial climate with 200- 250 cm annual rainfall (Grove, 1951).

The city of Owerri and its environs have experienced immense population, agricultural and industrial growth since it became the capital of Imo state in 1976. This growing population and industrial activities have caused, and will continue to cause, great stresses on water resources in the area. The water needs of Owerri are expected to rise to about 11 .4 million m^3/day by the year 2000 (Egejuru, 1987). This volume of water would be supplied by surface and groundwater systems conjunctively.

Presently, the major source of surface water supply to Owerri and its environs is the Otamiri River, while boreholes provide a source of groundwater supply.

GEOLOGY

Owerri lies entirely within coastal plain sandstones (Benin Formation) which have a thickness of about 800 m. The Benin formation extends from the west across the Niger Delta and southward beyond the present coastline. It is over 90 percent sandstone with minor shale intercalations in some places. It is coarse grained, gravely, locally fine grained, poorly sorted, sub-angular to well-rounded, and bears lignite streaks and wood fragments. The Benin formation is thus partly marine, partly deltaic, partly estuarine and partly lagoonal and fluviolacustrine in origin (Reyment, 1976). Its age ranges from Miocene to recent. The terrain of the area is characterized by two types of land forms: highly undulating ridges and nearly flat topography. Various structural units (point bars, channel fills, natural levees, back swamp deposits and oxbow fills) are identifiable within the formation indicating the variability of the shallow water depositional medium. The otherwise continuous body of the Benin formation is interrupted by the Afam clay member which consists mainly of clay with few intercalated sandstone bodies.

Stratigraphically, the Benin formation is overlain by recent alluvium and recent sediments and underlain by the Agbada formation. Its outcrop lateral equivalent is probably the Ogwashi-Uku-Asaba formation (Figure 1).

The study area is drained by two rivers, namely the Otamiri and Nworie. The Otamiri river has maximum average flow of 10.7 m^3/s in the rainy season (September - October) and a minimum average flow of about 3.4 m^3/s in the dry season (November - February). The total annual discharge of the Otamiri is about 1.7 x 10^8 m^3, and 22 percent of this (3.74 x $l0^7$ m^3) comes from direct runoff from rainwater and constitutes the safe yield of the river (Egboka and Uma, 1985). The depth to groundwater varies from 15m - 35m in parts of the Owerri urban area. The aquifers have reasonable thickness and are extensive (Ibe et al., 1992).

Hydrogeology and Groundwater Development

The study area is underlain by the Benin formation of Miocene to Recent age. This constitutes the sedimentary formation which contains the aquifers. The geology controls the occurrence and type of aquifers as shown in Figure 2.

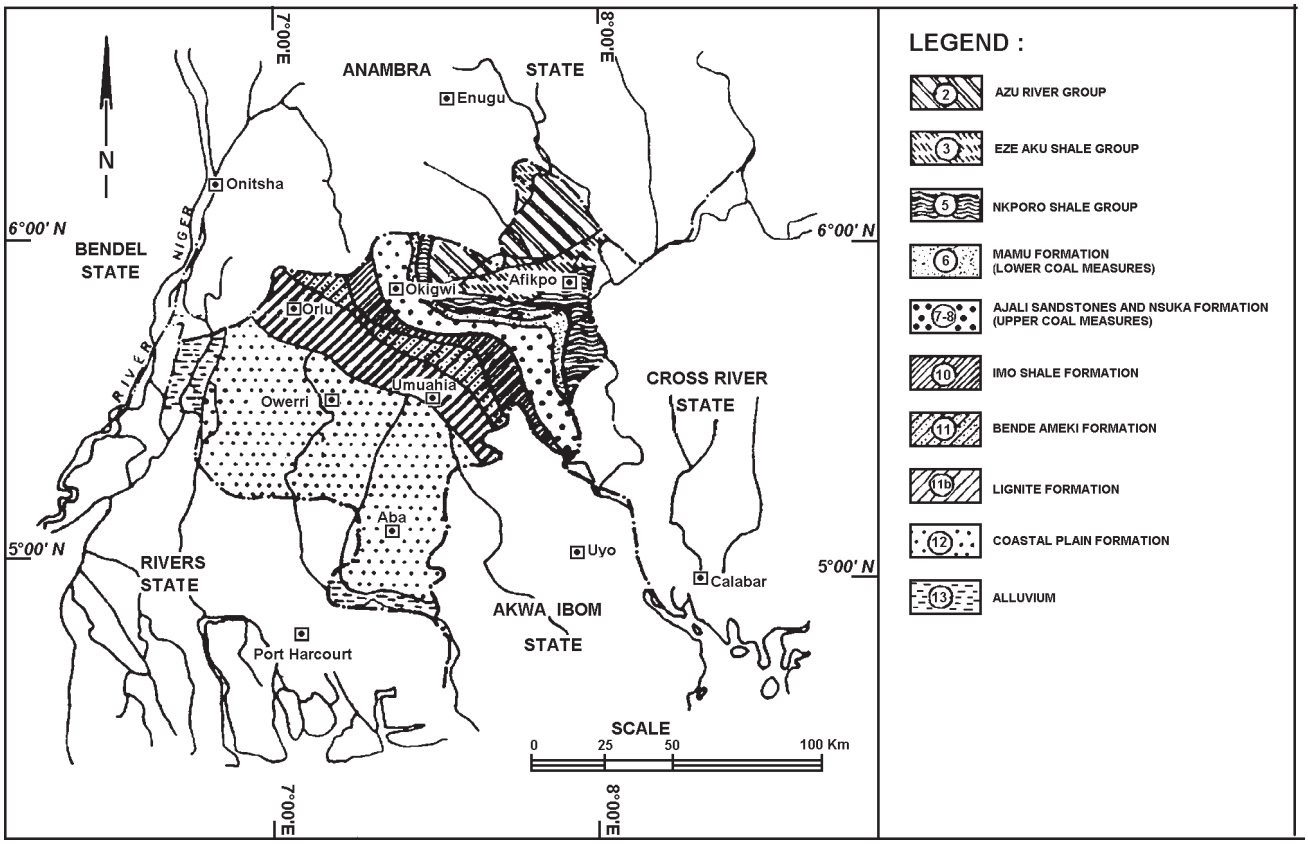

Figure 1. Geological map of Imo State.

The underlying Benin formation consists of thick unconsolidated sand interfingered with clay sand lenses. The sand and clay intercalations constitute a system of aquifers separated by aquitards.

Boreholes penetrating the upper 200 m of the area reveal the existence of 3 aquifer systems. Medium to coarse grained, to sub-angular coastal sand forms the aquifers, whereas the clay and the clayey fine grained sands form the aquitards.

The upper aquifer is unconfined and is present throughout the area. The porous materials are medium to coarse grained sands. The middle aquifer is semi-confined to confined, and has a thickness range of 30 - 40 m. The porous materials are sandy but lenses of fine grained clayey sand also occur. The aquifer is extensively tapped by boreholes.

The aquitard separating the aquifers is made up of 3-15 m thick sandy clay. This aquitard has a high leakage factor. Recharge occurs from rainfall and surface river flow (Uma, 1984). Presently boreholes also tap the middle aquifer.

SURVEY METHODS

In view of future economic development it becomes necessary to carry out a detailed hydrogeological investigation to assess the water resources in the study area so as to ensure maximum and continued water availability as well as the protection of the water resources. Indiscriminate pollution of the environment by man as a result of urbanization has created natural hazards within the capital city of Owerri. The swift flow of the rivers has been blocked by debris which has led to outbreak of diseases such as malaria, typhoid fever and cholera. The understanding and the study of environmental pollution processes is critical to the future of Owerri.

A short term field survey of the Otamiri and Nworie rivers was carried out in order to locate important sources of pollution. The stations were chosen such that water samples reflected the

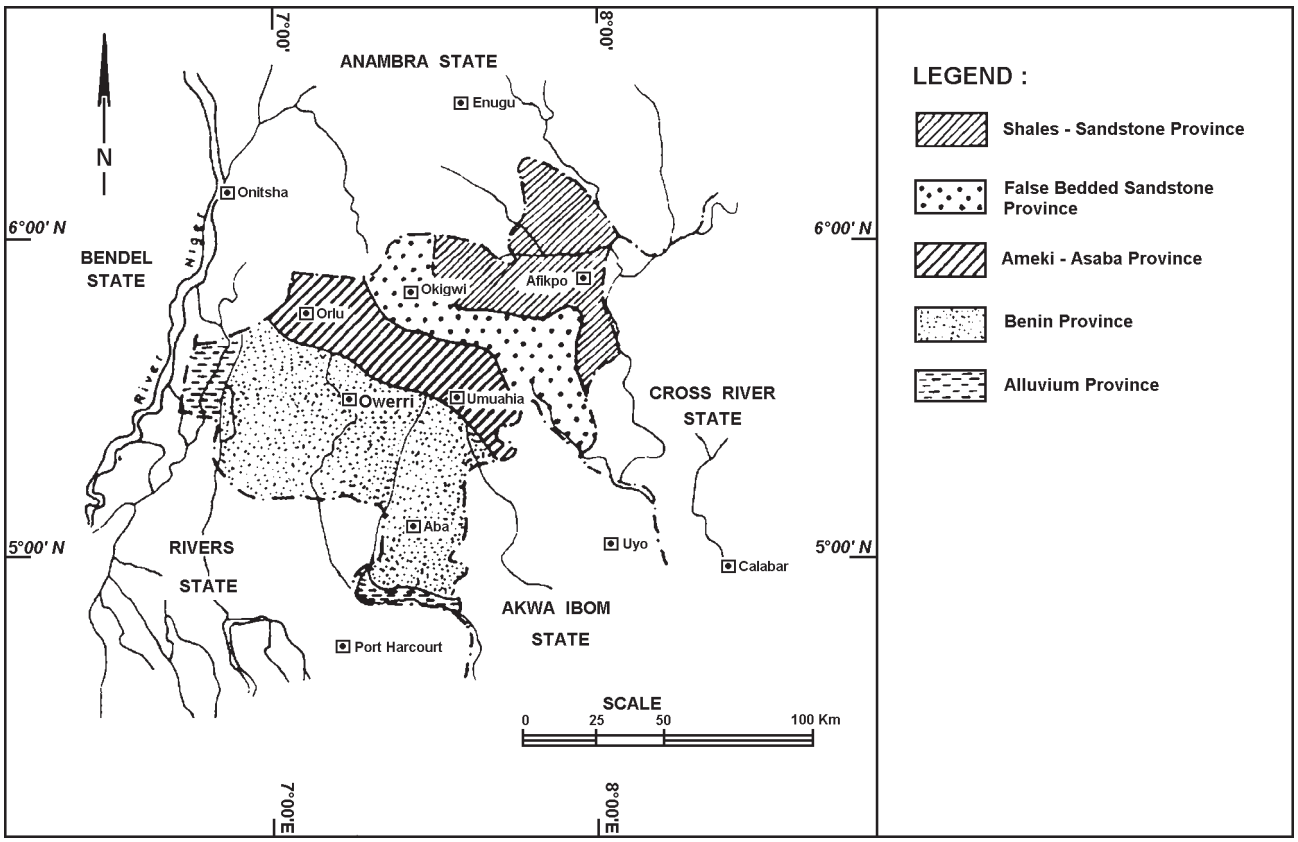

Figure 2. Hydrogeological provinces of Imo State.

inflowing and outflowing river water with respect to the source locations. The hydrochemical analysis of the water samples (Table 1) was carried out in the geological laboratory of the Federal University of Technology of Owerri using a portable Hach DR- EL / 5 Laboratory Kit. A grain size analysis was carried out for sediments. Based on a map with the scale 1:20,000, a land use map was produced (Figure 3; Ibe et al., 1992) that presents the spatial distribution and concentration of population, industry, agriculture, undisturbed areas, and other features related to the environment.

Table 1. Geochemical Parameters of Otamiri Samples: 1984, 1985, 1986, 1987, and 1997

GEOCHEMICAL PARAMETER	OTAMIRI May	OTAMIRI May	OTAMIRI May	OTAMIRI May	OTAMIRI May
mg/l	1984	1985	1986	1987	1997
Na^{+}	6.31	6.38	6.42	6.50	6.61
Mg^{++}	3.31	3.35	3.42	3.45	9.17
Ca^{++}	2.34	2.38	2.40	2.43	4.85
Fe^{++}	0.05	0.07	0.08	0.08	0.30
HCO_3	11.50	11.53	11.58	11.84	15.51
NO_3	8.41	8.81	8.45	8.80	50.1
SO_4	2.60	2.80	3.07	3.02	5.31
TDS	50.00	50.60	53.00	55.00	60.2
pH	5.10	5.20	5.30	5.50	6.4

Source: 1984, 1985, 1986 Sample data, Imo State Water Board: 1987 Sample date (Egejuru 1987); 1997 Sample date; Field Survey

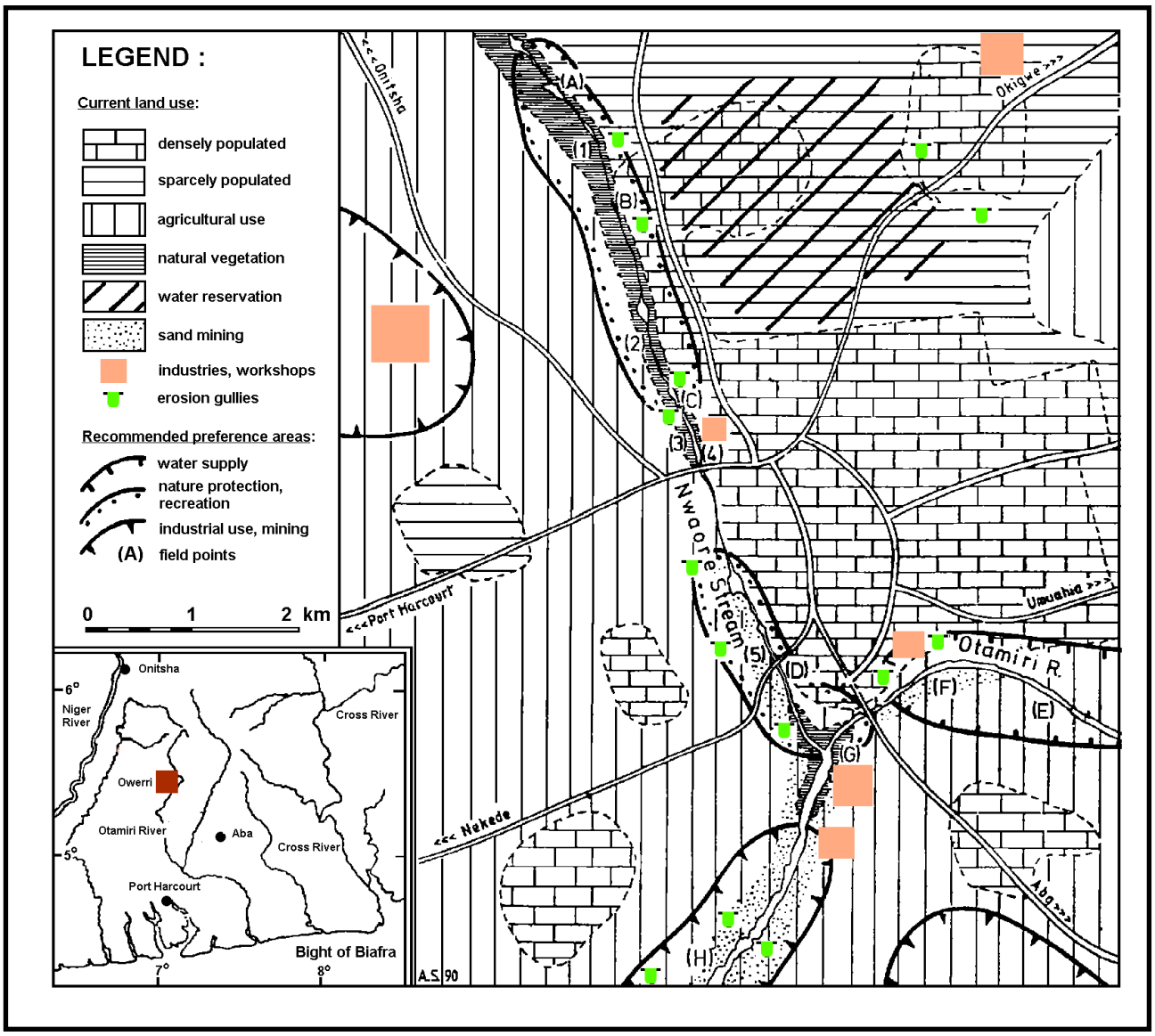

Figure 3. Map of land use and usage claim of the Owerri urban area.

The evaluation of the hydrochemical analysis and the land use map bring out the impact of rapid population growth, human activities and urbanization in degrading the quality of surface water resources.

RESULTS AND DISCUSSION

Surface and Groundwater Geochemistry

Water chemistry of rivers depends upon the size of the catchment area, the hydrogeological regime, type of landscape and economical activity of the population. Therefore, the major ion chemistry of the rivers varies greatly (Figure 4). The total dissolved solids range from 50.0 mg/l to 115.42 mg/l in the Otamiri river, and 100.5 mg/l to 107.5 mg/l in the Nworie river. Magnesium ion concentration ranges from 4.23 mg/l in the Nworie river to 10.21 mg/l in the Otamiri river. The impact of city growth on the Otamiri and Nworie water quality is reflected in the values of certain constituents (nitrates, magnesium and iron; Tables 1, 2, 3a and b). Nitrate was 8.3 mg/l in the Otamiri river (dam-site) in 1984 but by 1997 it has risen to 50.1 mg/l. The Nworie river ranges from 49.3 mg/l upstream to 65.1 mg/l downstream. Generally, it is observed that the concentration of nitrates is on the increase

Table 2. Geochemical Parameters of Nworie and Otamiri Water Samples

LOCATION	N^+	Mg^{++}	C^+	Fe^{++}	HCO_3^-	$P0_4^-$	NO_3^-	SO_4^-	pH
A	6.3	8.0	5.6	0.0	16.5	2.3	56.3	8.0	6.5
B	6.4	10.0	5.6	0.0	16.4	2.3	56.7	8.0	6.6
C	6.4	10.2	5.7	0.1	18.6	3.1	57.3	8.1	5.1
D	6.4	10.3	2.3	0.1	16.6	4.2	60.2	8.2	5.0
OTAMIRI RIVER									
E	6.3	3.4	2.4	0.0	18.0	1.1	50.0	4.0	6.0
F	6.4	3.4	2.4	0.0	10.0	1.1	50.8	4.0	6.3
G	6.4	3.4	2.4	0.0	19.1	2.0	51.2	4.2	6.3
H	6.5	10.4	5.4	0.0	16.6	4.2	51.2	8.3	5.0

Table 3a. Geochemical Parameters of Nworie River (1997)

LOCATION	NO	Na^+	Mg^{++}	Ca^{++}	Fe^{++}	HCO_3^-	$P0_4^-$	NO_3^-	SO_4^-	TDS	pH
FED HOUSING	1	6.3	7.74.	6.38	0.30	17.5	3.19	49.3	10.0	100.5	6.3
HOSPITAL	2	6.56	9.32	7.20	0.34	18.0	3.21	50.1	10.5	100.5	5.8
OWERRI/NEKEDE	3	6.56	9.32	7.20	0.35	18.2	3.30	57.1	10.3	107.1	6.5
EMMA. COLLEGE	4	7.01	11.48	7.53	0.40	18.5	3.20	65.1	10.89	107.5	6.5

Table 3b. Geochemical Parameters of Otamiri River (1987)

LOCATION	NO	Na^+	Mg^{++}	Ca^{++}	Fe^{++}	HCO_3^-	$P0_4^-$	NO_3^-	SO_4^-	TDS	pH
BEFORE DAM	5	6.61	9.17	4.85	0.30	15.51	0.8	50.1	5.31	60.2	6.4
ABA ROAD	6	6.70	10.21	5.0	0.42	17.7	1.42	50.8	8.22	81.14	6.8
CONFLUENCE	7	6.72	13.22	5.35	0.30	18.2	4.15	50.15	8.37	113.61	6.84
F.U.T.O.	8	6.60	14.4	5.86	0.32	20.2	5.01	63.3	9.15	115.42	6.4
TREATED WATER	9	5.56	1.04	2.46	0.28	20.5	0.8	1.0	1.0	50.0	6.8

as urbanization increases. This increase is attributed to surface water flowing from the farmlands, recreation areas, industrial effluent and the indiscriminate disposal of solid wastes into the rivers. The contamination of the rivers would end by an immediate stoppage of disposal of wastes into the rivers, planned waste disposal and properly managed landfill programs.

Potable water from the aquifers in Owerri is of good quality. The total dissolved solids ranges from 250 - 500 mg/l. Nitrate ranges from 17.2 - 66 mg/l. But it is observed that there is a gradual increase in concentration with increasing urbanization. Other ions that appear to be on the increase are carbonates, calcium, chlorine and magnesium ions. These increases can also be attributed to industrialization, nutrients from farm lands and improper waste disposal methods. A waste treatment plant is therefore recommended.

The results of geochemical analysis show that both the surface and groundwater have high concentrations of nitrate, carbonates and total dissolved solids . Potential sources of these are soaps, detergents and agricultural fertilizers, and the use of septic tanks. As the population increases there will be a need for more extensive farming to feed the population as well as an increase in the use of septic tanks. Hence more wells will withdraw groundwater whose nitrate, carbonate and total dissolved solids exceed the WHO guidelines(WHO, 1971).

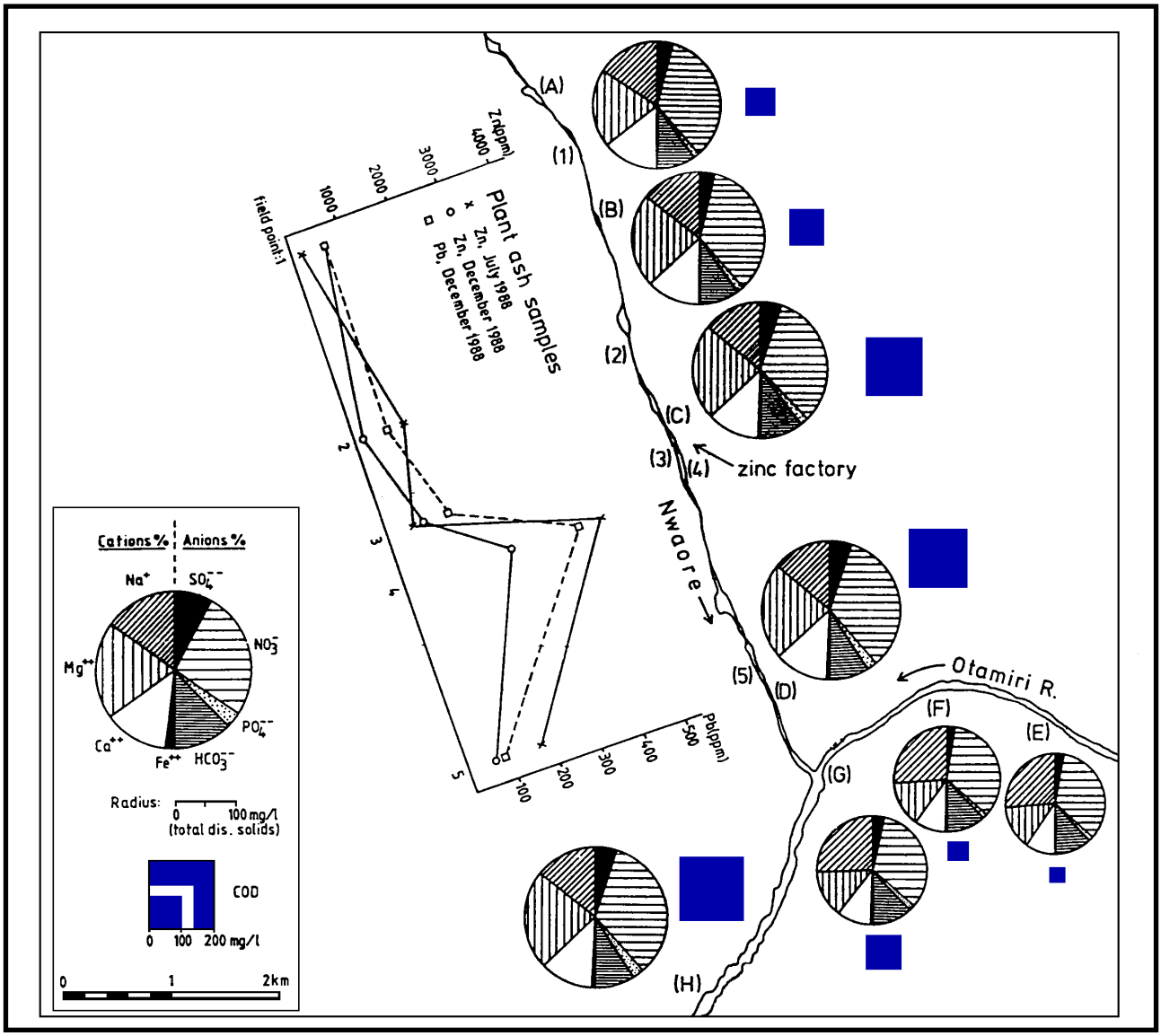

Figure 4. Hydrogeochemistry of the Nworie and Otamiri Rivers.

Protection of Water Resources and Expansion of the City

Owerri was originally an agricultural settlement made up of five villages. Until 1976, almost all development occurred on the east side of the Nworie river following mainly the Aba-Douglas-Hospital road direction, forming the core of Owerri town together with the five traditional villages. A segment of the population is served with house connections to water supply while the rest obtain water from public taps. Although the aquifer is good, the available volume of water does not meet the demands during peak periods (December - January). Today, the water supply has been improved with the provision of separate boreholes to serve communities, while the treated surface water of the Otamiri river serves the other parts of Owerri.

A proper refuse disposal program was handicapped by under staffing, inadequate funds and lack of equipment. Refuse was often dumped in the streets, streams and ravines because of the unsuitable location of refuse collection points. Today, although these conditions still exist, many improvements have been carried out, especially on the provision of equipment.

The city was to provide an urban structure that created a well balanced distribution between the major land uses as well as the various socioeconomic groups. Land uses and their locations were

designed to provide a high quality of physical environment, and to provide an urban structure flexible enough to deal with the uncertainty about future changes in population, income, employment and human needs.

Waste water from residential areas must be collected by means of a drainage system, drained from the built-up areas and cleansed before it is passed on to be used for irrigation purposes. Only in this way can hygienic standards be kept high, and open water preserved in its natural condition. Waste water and storm water were meant to be drained separately. The area surrounding Owerri is very flat with a slight gradient towards the southwest. With respect to drainage and the preservation of the water quality of the Otamiri and Nworie rivers within the built up area, the area between Umu-Alum and the Otamiri river seems to be the best location for the central sewerage treatment plant (Fingerhuth, 1976).

In future planning of the growth of Owerri, various factors should be considered in order to protect the surface water and groundwater resources. These factors include the distribution of the resources, the degrees of their natural protection, status of their quality, and present or future impact of groundwater withdrawals upon them. The siting of a waste water treatment plant in which the waste from the city could be collected, treated and the sludge used as manure, while the resulting water could be sent out for irrigation purposes, is recommended.

The investigation shows how human activity disturbs the natural system by a destructive exploitation of the natural resources by agricultural production and mineral resources extraction. To protect the water resources of Otamiri and Nworie rivers, a proper land use planning map is required (Ibe et al., 1992). To do this, the scientific records of all conflicting parameters controlling the ecological system, and the exact knowledge of their geographical distribution and significance is necessary for the delineation of usage claims clue to different demands. Based on this, agricultural use, mineral resources extraction and environmental protection generate determinants for the land-use planning map (Figure 3).

CONCLUSIONS

Rational and ecologically optimal planning of modern city growth should include evaluation of economic and environmental protection, as well as other factors. Owerri and its environs were appraised from the point of view of the evaluation and protection of surface water (Otamiri and Nworie rivers) and groundwater (unconfined and confined aquifers). Hydrogeologic and hydrologic data were gathered and analyzed, and special investigations of small extent were carried out for this purpose.

The results of investigations indicate that anthropogenic pollution in the central part of the city and in industrial areas occurs in the shallow unconfined aquifers and in the deeper confined aquifers. The city also negatively impacts sources of surface water supplies.

In an effort to protect the quality of water resources of the city and to prevent their deterioration, two types of areas that could impact city growth are proposed that integrate various natural and anthropogenic factors: (1) most beneficial and suitable, and (2) unfavorable and unsuitable. The first type is most favorable for city growth of any kind. In unfavorable areas, only civil construction would be allowed.

Reconstruction of already developed areas is not recommended here. Areas of acute, conflicting environmental conditions, where urgent measures to improve water resources protection are

presently required, have been designated unsuitable for city growth (Fingerhuth, 1976). No large new buildings or essential changes of existing buildings are recommended here. Development of the second types of area in all cases should be preceded by detailed hydrogeologic studies.

In an effort to protect the quality of water resources of the city and to prevent their deterioration, a treatment plant is recommended to be sited at Umu-Alom (Nekede) as well as stoppage of both industrial and domestic waste effluent discharged into the rivers.

Indiscriminate deforestation should also bediscouraged because it leads to erosion. Increased soil erosion leads to stream degradation with deposition of material in the upper and middle course of the river. Furthermore, efforts should be made to assure continuous monitoring of levels of pollution due to environmental and other anthropogenic impacts.

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