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WATERBORNE SANITATION IN NIGERIAN CITIES

INTRODUCTION

The central sewerage system remains the most satisfactory method for the treatment and disposal of municipal wastewater and it is the method adopted in most cities in the countries of Europe, America and other parts of the developed world. It is also the ambition of towns in the developing countries where in many cases sanitation facilities are very poor indeed to have the central sewerage system.

Both enlightened opinion in Nigeria and the world health community have from time to time expressed concern over the grossly inadequate facilities for sanitation in Lagos the Federal Capital of Nigeria. Succeeding Governments have for some fifty years been commissioning Consultants to look into the problem. Each time the consultants have made proposals for waterborne sanitation. But each time the Government has found that the difficulties associated with the implementation of these proposals have been so great that the proposals have had to be shelved. Unfortunately, when a decade or so after a succeeding Government turned again to the proposals, they were found to be already out of date and that the difficulties associated with the implementation on the earlier occasion have become more complex.

Problems of Waterborne Sanitation in Nigeria:

The inability of successive Governments to implement the proposals for a central sewerage system in Lagos is due to the serious problems associated with the central sewerage system as an engineering service (ref.1). High capital cost is the first of these problems. The Consultants for the 1966 proposals for the drainage and sewage disposal facilities for Lagos estimated that the scheme would cost £178m for 4.35m people which was the estimated population of Lagos in the year 2005, the end of the design life of the project (ref.2). This works out at £41 (₦92) per capita for both liquid and solid waste collection and disposal. The latter, however, accounted for less than ₦2 leaving the capital cost of the liquid waste facilities at a solid ₦80 per capita.

An analysis of ten water supply projects

carried out in the then Western Nigeria in the five year period 1961-66 showed that the per capita cost of these supplies varied from £3.23 in Oyo (pop. 271,500) to £11.65 in Shaki (pop. 50,000). The average per capita cost was £4.62 (₦9.64) for an average population of 169,400. From the little information available on electricity capital costs in Western Nigeria during this same period, the average per capita cost appeared to be just under £4 (₦8.00). The conclusion from this analysis is that sewerage is by far the most expensive of these three engineering services (ref. 1).

This very expensive engineering service has about the lowest political appeal in the comity of engineering and social services which compete for Government's attention in the allocation of scarce financial resources in the annual budget. With the exception of a few pumping stations and the structures of the sewage treatment works, usually tucked away in an out-of-the-way area of the city, nearly most parts of a sewerage project are literally buried underground. This contrasts with water, electricity, schools, hospitals, roads and bridges which not only cost much less, but actually exist, in most cases, as imposing structures which the electorate can see for themselves.

Added to the high capital cost, the physical construction of a network of sewers in an existing town will lead to dislocation of traffic and general dis-organisation of business life. This will be so in view of the poor town planning in the first instance, which has resulted in most cases in narrow streets with inadequate building line on them. In addition, there is the need for public acquisition of land and property which could be a time consuming and frustrating experience. In the older parts of towns like Lagos and Ibadan, the streets are so narrow and winding that they are hardly discernible, and individual buildings hardly face on to any recognisable streets and follow any identifiable building line. The excavation for and the laying of sewers in these areas becomes practically impossible without combining it with slum clearance, together with attendant re-housing problem (ref. 1).

Finally, the usually held view that Africa is

a continent in which natives live in a very large number of villages and collections of huts is not true in Nigeria where there is a great incidence of urbanism, particularly in the South Western part of the country. The 1963 Census showed that there were at that time 23 towns with populations of 100,000 and over in Nigeria, sharing a total population of 5,043,386 or 9.1% of the total population of 55,670,046 for the whole country. Fourteen of the 23 towns are situated in the area now covered by the states of Oyo, Ondo, Ogun and Lagos, all within a radius of 160 km of Ibadan in Oyo State. It is noted in passing that there was in 1963 no single town with a population of up to 100,000 in Liberia, Senegal, Mali or Gabon; Sierra Leone, Uganda and Tanzania had one such town each; Ethiopia, Kenya and Sudan two each; and Ghana three. The process of urbanism has of course progressed since 1963 and many more towns than 23 can now be expected to have exceeded the 100,000 mark.

The main problem posed by a big town is the relatively high capital cost of a sewerage scheme compared with other government projects like schools, hospitals and water supply. Had the population of Lagos been 122,000 in 1965 instead of 1,220,000, the £178m estimate for the proposed central sewerage scheme would come down to a very much smaller figure which the Government might have found more acceptable. The interesting inference here is that the outlook for municipal waterborne sanitation is brighter in the smaller towns than in the larger ones.

Sewerage Capital Costs:

An analysis of the consultants' estimate of the capital cost of the Lagos Central Sewerage and solid waste disposal proposals is quite revealing. The sewerage component alone was estimated to cost £126m or 71% of the estimated total cost of £178m, the treatment plant, pumping stations, and the solid waste disposal components all costing only 29% of the total cost (ref.2). A similar analysis of waterborne sanitation installation for what is most probably Nigeria's first town with the central sewerage system, the Black Arts Festival Town (FESTAC CITY) off Lagos-Badagry Road in Metropolitan Lagos, shows the total cost to be ₦11,72m for a design population of 75,000 which works out at ₦156.27 per capita, 1975 prices. The sewerage component of this cost is ₦6.53m or 55.7% (ref. 3,4).

The extra cost of land and property acquisition and of excavating for and laying sewers in an existing city of the complexity of Lagos would, no doubt, account for part of the disproportionately high cost of the sewerage component in the Lagos proposals. It will probably be found however that even when adjustment has been made for this, the sewerage component cost is still relatively high.

The Gilbert Associate proposals for Lagos under

discussion cover an area of some 100km² and would cater for a design population of 4.35 million. Festac City, on the other hand, covers an area of only some 16km² while the sewerage scheme will cater for a design population of just 75,000. Ibadan, the capital of Oyo State however, does compare more favourably in size with Lagos than does Festac City. Luckily too another firm of consultants, MacLaren International, did submit to the then Western State Government in 1971 a Master Plan for Wastes Disposal and Drainage for Ibadan (ref. 5). The area covered by the Master Plan is roughly 140km². Details of the population catered for in the Ibadan proposals are not immediately available, nor are they seriously relevant. What is relevant however is the fact that the sewer sizes mentioned in the scheme appear to range between 8 inches (200mm) to 60 inches (1.5m). The Lagos proposals do not get down to sewer size details but sizes of 60 inches (1.5m) were mentioned in parts of the Report. The largest sewer in the Festac City scheme appears to be 900mm, with the average size being much smaller than this.

Understandably, sewers start being small from the beginning of a scheme where the sewage flow is small. They then increase in diameter as more and more tributary sewers join them bringing in more sewage to increase the flow. This continues until a particular sewer terminates in another sewer or at a pumping station or flows into an outfall sewer, which in most cases will be the largest sewer in a scheme. It is understandable then why the largest sewer in a small town like Festac City is smaller than the largest sewer in a big town like Lagos or Ibadan.

Table 1 is compiled from one of the tender documents submitted in 1975 for the construction of the Victoria Island Sewerage Scheme in Lagos (ref. 6). It shows the variation of cost per unit length of reinforced concrete pipes with increasing diameter, the cost including the actual pipe supply and laying operations but excluding earth excavation and back-filling. Fig. 1 drawn from Table 1 is not a straight line but a smooth curve which shows that sewer construction cost varies logarithmically with diameter. For this particular curve the following relationship has been developed:

$$C = 0.11 d^{1.69} \quad (1)$$

where C = cost per foot of sewer, in Nigerian Naira

d = diameter of sewer, in inches.

The gradient of this curve is the same as that of the curve developed from Table 2 showing the results of a study in reinforced concrete sewer constructions costs in Kansas City, U.S.A. reported by Howells D.H. 1964 (ref.7):

$$C = 0.55 d^{1.70} \quad (2)$$

where C = cost in US dollars/ft of sewer, d = diameter of sewer in feet.

TABLE 1

REINFORCED CONCRETE SEWER PIPE COSTS
VICTORIA ISLAND (1975)

Pipe diameter (inches)	Cost/ft length ₦	Cost/dia.inch/ (ft/length)
20	17.40	0.87
21	17.40	0.85
24	23.70	0.90
27	28.00	1.04
30	33.60	1.12
33	39.80	1.21
36	45.00	1.25
42	60.60	1.44

$$\text{Cost} = 0.11 (\text{diameter})^{1.69}$$

TABLE 2

REINFORCED CONCRETE SEWER PIPE - KANSAS CITY
MO., AUG. 1, 1962

Diameter of pipe in ft.	Cost/ft of length	Cost/diameter in ft of length
0.67	₦0.296	₦0.037
1.00	.744	.062
1.50	1.188	.066
2.00	1.752	.073
2.25	2.214	.082
2.50	2.580	.086
3.00	3.492	.097
3.50	4.536	.108
4.00	5.712	.119
4.50	6.966	.129
5.00	8.460	.141
5.50	9.966	.151
6.00	11.952	.166
7.00	14.784	.176
8.00	19.488	.203

$$\text{Cost} = 0.55 (\text{diameter})^{1.70}$$

The analysis of Table 1 shows that a 30 inch (750mm) diam. sewer costs approximately twice while a 42 inch (1.05mm) diam. sewer costs approximately 3.5 times a 20 inch (500m) diam sewer. It explains why the average cost per unit length of sewer in a project is greater in a scheme with greater incidence of large diameter sewers than in another scheme in which there are few large diameter sewers. It explains why the Lagos Sewerage proposals which have a much larger incidence of large diameter sewers must cost more than the Festac City scheme per unit length of sewer since there are few large diameter sewers in the latter scheme. This fact must partly account for the relatively low figure of 55.4% which the sewerage cost bears to the whole scheme in the Festac City scheme compared with 71% in the Lagos proposals.

Thesis for an Interim Programme of Waterborne Sanitation in Towns

It is postulated here that while the difficulties earlier analysed will continue to make the outlook for the central sewerage system in existing towns in Nigeria bleak, there are areas of these towns that can now enjoy the benefits of limited waterborne sanitation facilities provided a number of criteria are met. The first of these criteria is the existence of an area either owned or under the control of an authority that recognises the advantages of waterborne sanitation and is both willing and able to pay for these facilities in the area under its control. The second criterion is the need for development concerned not to be extensive in area. The largest sewers in an estate that is only

a few square kilometres in area will in all probability not be bigger than 450mm to 600mm diameter. The cost of sewer construction per unit length will be relatively small in such an estate according to the case already established above.

The domestic septic tank is the simplest example that meets the two criteria. Here a single building developer undertakes the capital cost of a sewage disposal device which serves an area that is so small that the sewerage component is reduced to the very minimum possible, a 100mm diameter pipe of some 3 to 10 metres length. Other cases that will meet these criteria are primary and secondary schools, Universities, hospitals, police barracks, military barracks, industrial estates. Others yet are government residential areas, housing estates, resettlement schemes and satellite towns.

The few waterborne sanitation facilities in Nigeria are those installed in pockets of developments in towns in which the criteria described above have been satisfied. A short account of some of such facilities in the Lagos Area will now be given. Fig.2 shows a map of the Metropolitan Lagos Area and the location of the treatment plants mentioned.

Waterborne Sanitation Installations in Lagos:

The first of these waterborne sanitation facilities in Lagos is the 50,000 gallons (227.5m³) per day capacity "Oxigest" Model 31R80 package plant installed in the University of Lagos in 1965 to cater for the canteen, domestic and laboratory wastes from a student population of 1000. It is a contact stabilisation modification of an activated sludge process plant. The treatment plant caters for buildings in an area no larger than 1 to 2 km².

The second example is the treatment plant serving the Military Cantonment of the Nigerian Army in Ikeja. The Cantonment covers an area of some 2km², and consists of the usual accommodation for officers and other ranks, offices, a hospital and other facilities. The raw sewage from these buildings is carried in an 18 inches diam. concrete gravity sewer to the treatment plant some two and a half kilometres away at the edge of the swamp the other side of the heavily trafficked Ikorodu Road. The ultimate design population is 18,000. The treatment plant is the conventional trickling filter preceded by primary clarifier and followed by a secondary clarifier, a sludge digester and sludge drying beds.

The third of the installations in Lagos is the Ikeja Industrial Estate Trade Effluent Plant. The original plant had a design capacity of 640,000 gallons (2912m³) per day and was meant to serve all the factories in the 0.75km² Estate. However only a very few of the factories were connected to the plant, which was out of order for long periods at a time. The 1965 cost was £500 which worked out at

£31.2 per capita for a 16,000 population equivalent which is rather high.

Another Oxigest plant of 200,000 gallons (910m³) per day capacity was built by the Lagos State Development Corporation in 1966 to treat the sewage from a group of 45 buildings covering an area of just 29 acres (0.12km²) in one of its housing estates in Surulere. The capital cost in 1966 was £61,000 or only £12.2 per capita.

In 1967 a plant similar to the plant at the Ikeja Military Cantonment was built for the Nigeria Police at the Southern Police College, Ikeja. It has a design capacity of 45,000 gallons (205m³) per day to serve a population of 1500. The budget cost in 1966 was £28,350 which works out at £18.9 per capita.

Finally, a Clow Model CS-660-F7-100 plant was built in the Lagos Teaching Hospital in 1976. It is like the "Oxigest", with a design capacity of 660,000 gallons (3003m³) per day and a total BOD loading of 1650lb (750 kg) per day. The 1976 estimated cost was ₦473,000 which at an assumed population equivalent of 11,900 works out at ₦39.74.

It is mentioned in passing that a number of the treatment plants mentioned here were either out of order or were functioning inefficiently when visited in the last two years. One thing or the other had gone wrong which had not been put right either due to lack of knowledge of what to do or the non-availability of essential spare parts.

Government Reservations, Housing Estates, Satellite Towns:

Government reservations and housing estates are developments usually physically separated from existing towns and they are usually in many cases not bigger than university campuses or military barracks in size. They satisfy the conditions of development being under single control and of reasonably small size compared with towns. Unlike existing towns government reservations and housing estates have usually followed good town planning layouts with good building lines. They therefore are easily amenable to the construction of new sewerage schemes at no prohibitive cost to Government or the organisation that owns the housing estate;

It is not a very wide hop from a housing estate or Government reservation catering for 10,000 people to a satellite town in which 20,000 to 50,000 people will live. Where such a satellite town is to be a new creation the sewerage scheme would be planned as one of the engineering services and installed as such as part of the land development from the very beginning. When however what is contemplated is the sewerage of an existing satellite town the case still satisfies the conditions of manageable size and development being under single control, and the scheme can therefore be carried out, possibly in phases.

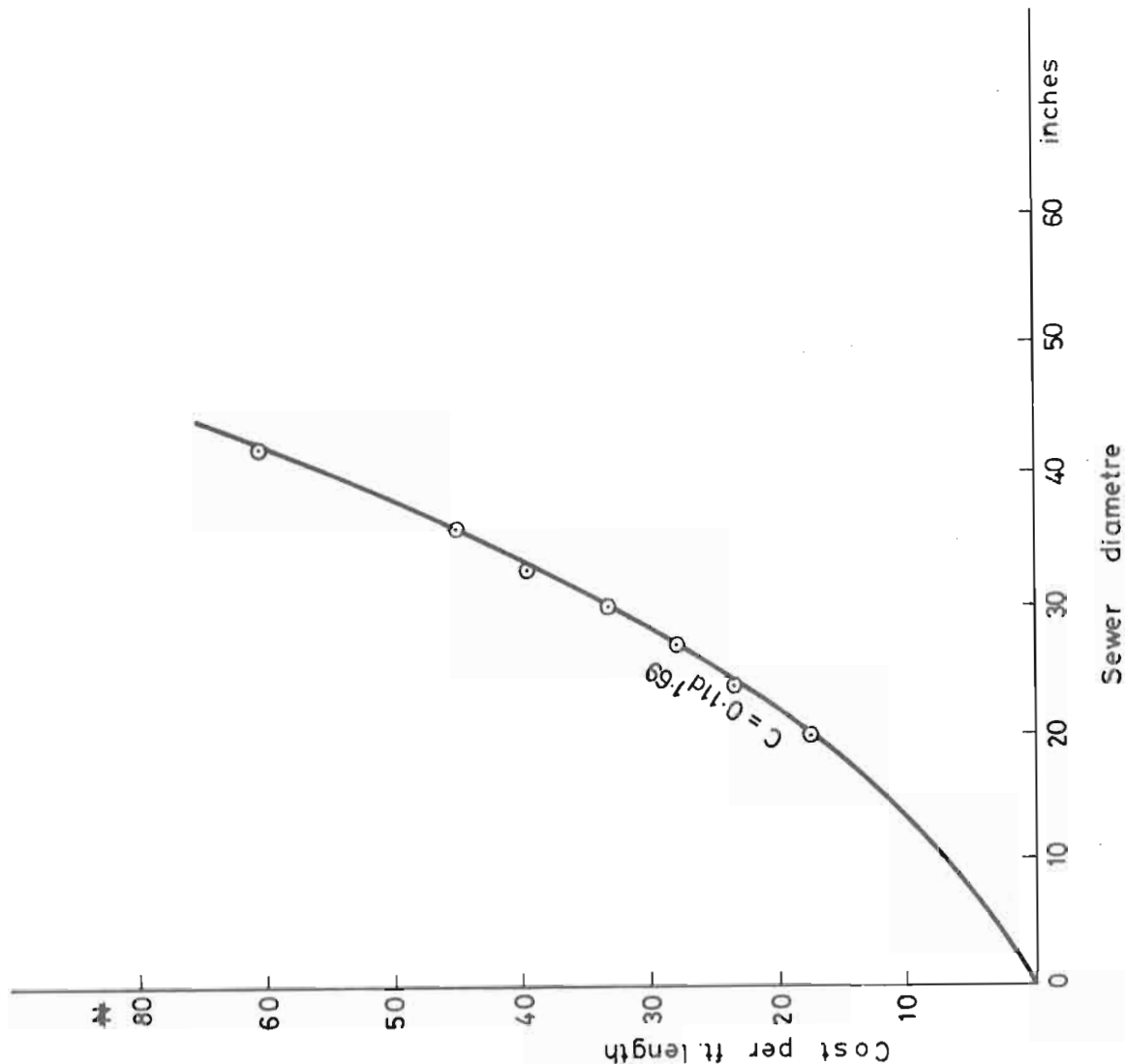


FIG.1. REINFORCED CONCRETE SEWER COSTS, VICTORIA ISLAND, 1975.

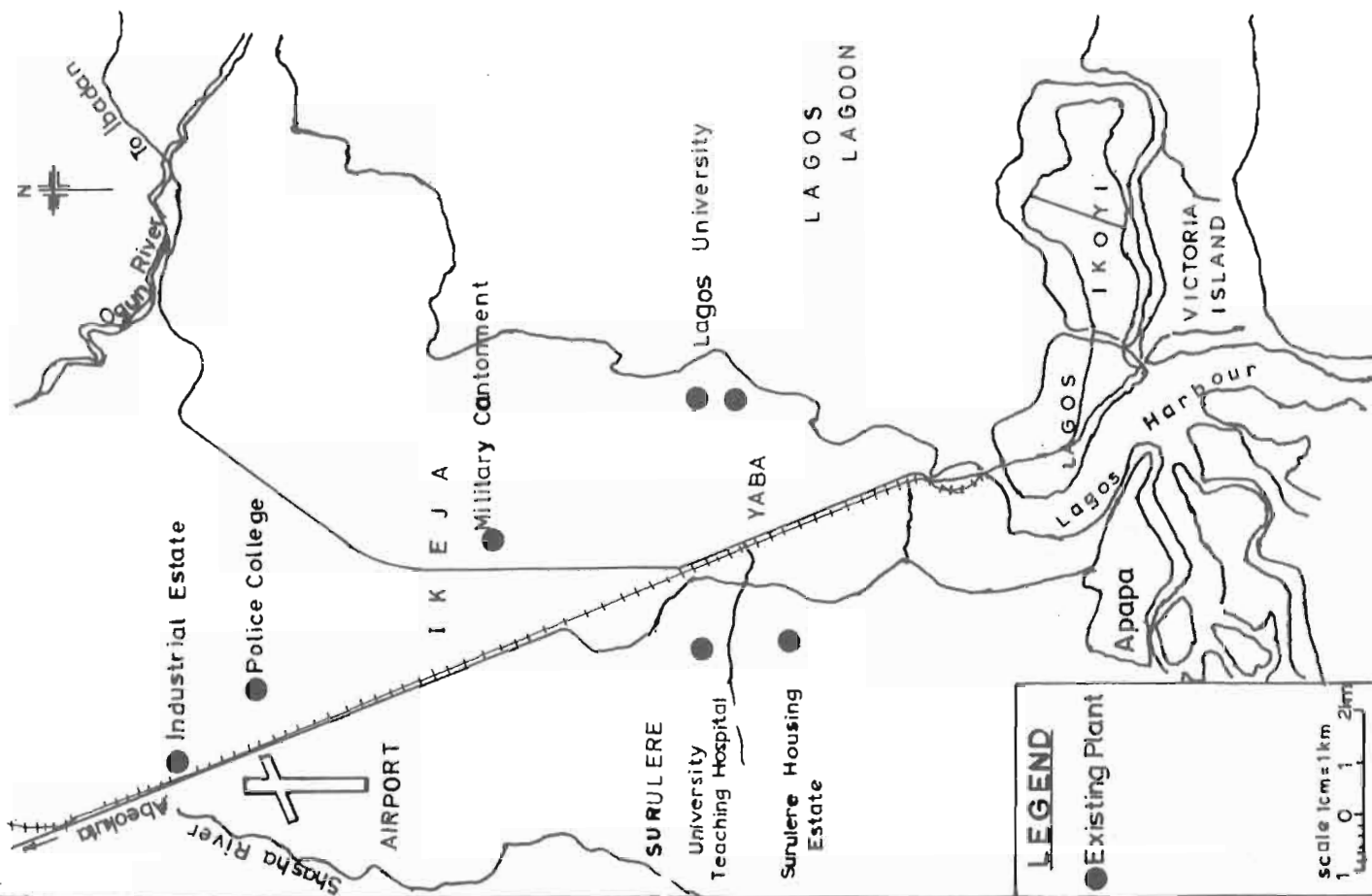


FIG.2. SOME SEWAGE TREATMENT PLANTS IN METROPOLITAN LAGOS.

CONCLUSIONS:

It is unrealistic to under-rate the massive problems of the central sewerage system in towns in Nigeria and other developing countries. They will make this highly desirable engineering service unattainable in these towns for quite a while. It is however possible to identify pockets of existing or proposed development inside or outside these towns which are small in size and are owned by authorities that are both able and willing to pay for the construction of waterborne sanitation facilities in them. Governments should embark upon an interim programme of sewerage schemes in such areas.

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