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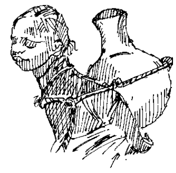

Low-cost urban sanitation in Nigeria

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LACK OF ADEQUATE and safe water supply and sanitation remain two of the main transmitters of disease in the world's developing countries. Water and Sanitation inadequacies also hinder economic and social development, constitute a major impediment to poverty alleviation, and inevitably lead to environmental degradation.

Under these conditions, a large proportion of the population in the developing countries has little if any chance for social and/ or economic development, and a poverty spiral is established for which poor basic sanitation conditions are one of the main foundations.

The sanitation system which is by far the most convenient to the user is the conventional water-borne sewerage system found in most European communities. However, water-borne sanitation system is inappropriate for most urban centers in developing countries on the ground of high capital construction cost, usage of large volume of potable water merely to transport wastes along pipes, complex technology and blockage among others.

Rationale for the work

By early in the twenty-first century, more than half of the world's population are predicted to be living in urban areas. By the year 2025 that proportion could rise to 60 percent comprising of some 5 billion people. This rapid urban population growth is putting and will continue to put, severe strains on the water supply and sanitation services in most major conurbations, especially those in developing countries (Jackson, 1995).

The World Health Organisation's figures for 1988 showed that only 67 percent of the combined urban population of the developing countries had adequate facilities for excreta disposal. Only a minority of these were served with piped sewerage system (World Health Statistics Report, 1989).

In certain major cities in Africa, for example, it is estimated that as many as two-thirds of the population are without adequate sanitation (Water Solidarity Network, 1994).

It had been calculated that communities with water borne sewerage normally require more than 75 litres per capital per day (lcd), compared with less than 20 litres per capital per day (lcd) in many squatter settlements (Cairncross and Feachem, 1993).

The study of "Water Supply needs in Nigeria for the 1990's and Strategies for Satisfying them" depicts that the the urban centres served (95%), have on the average 62 litres per capital per day (lcd) (Oyebande, 1990).

With the problem of inadequate water supplies in Nigeria that is 62 litres per capita per day (lcd) for the urban centres served (Oyebande, 1990) and knowing that communities with water-borne sewerage normally require more than 75 litres per capital per day (lcd)(Cairncross and Feachem, 1993).

It is evident that the possibility of reliable, conventional sewerage systems for the urban centres in Nigeria is not feasible.

Though various low-cost sanitation options are at work throughout the world, especially in countries with water shortages and with large urban populations. The existing sanitation options in most urban centers in Nigeria are majorly the on-site sanitation technologies (Oluwande, 1983).

The objective of the work is to carry out a cost optimization modelling by comparing the shallow sewerage systems with the existing on-site sanitation practices. Based on the cost optimization modelling, an appropriate lower cost sanitation technology would be chosen between shallow sewerage system and the currently practised on-site sanitation technology for the chosen urban centres in Nigeria.

Methodology

The work aims at testing the adaptation of the technology of shallow sewerage developed in Northeast Brazil to Nigerian system (Sinnatamby, 1983). Sinnatamby (1983) in his work states that above a certain population density (160 persons per hectare), shallow sewerage is cheaper than on-site sanitation technology currently been practised in Nigeria. A total of 30 urban centres was studied (state capitals and key urban centres).

Data used include the 1991 population of states of Nigeria by Local Government areas obtained from the National Population Commission.

The authors also made use of the Areas of Nigeria by states obtained from the Federal Surveys Department.

Data used also includes Nigerian household structure, percentage distribution of households by type of toilet facilities, percentage distribution of dwelling units by type of water supply and Nigerian basic health information all obtained from a general household survey as given in the Federal Office of Statistics Yearbook (1996).

Other data used for the work include the population , demographic, social and economic indicators (urban growth rate and urban percentage for Nigeria and Brazil) obtained from "The State of the World Population (1994)" published by the United Nations Population Fund.

The authors also made use of the urban percentage distribution of the source of drinking water and sanitation facility from the Nigeria Demographic and Health Survey (1990).

Other data used in his work includes water availability (per capita supply) for each urban centre in Nigeria given in the work of Oyebande (1990) on "Water Supply needs in the 1990's and Strategies for Satisfying them" published in the Water Resources Journal of the Nigerian Hydrological Association.

The authors also made use of the sanitation coverage for the urban centres in Nigeria published in the "WHO/ UNICEF Water and Sanitation Sector Joint Monitoring Programme" (JMP) Status Report for 1996.

Among other data used includes the average static (piezometric) water level for the chosen urban centres in Nigeria obtained from pumping test reports of boreboles from the Consultants handling the ongoing National Rural Water Supply Projects in Nigeria.

A projected population density and projected water availability was computed using computer applications (spreadsheet technology) at the end of the master plan sanitation period (year 2030) being projection from the 1991 population figures and 1990 water availability data in Nigeria.

Based on the projected population density, projected water availability, approximate static (piezometric) water levels and critical examination of existing sanitation practices, an optimum sanitation technologies is hence chosen for the urban centres in Nigeria.

Data analysis

As shown in Table 1: Computation of population densities for the chosen urban centres in Nigeria;

'k' = Population growth rate for the chosen urban centres in Nigeria obtained from the "State of the World Population (1994) published by the United Nations Population Fund. 'k' = 5.5% = 0.055

't' = Master plan sanitation period or the design period for the appropriate low cost sanitation technologies which is chosen as 1999 to 2030 based on urban water supply and sanitation design period given by the current conventional UK sewerage design covered by the British Standards 8005 (BSI, 1987) and sumarised in the design and construction guide for developers in England and Wales, entitled Sewers for Adoption (WSA, 1995) recommends 30 years as a planning horizon.

Hence, based on population projection from the 1991 population figures and choosing 30 years as a planning horizon, 't', the design period = 39 years.

$\mathbf{UP_{1991}}$ = Population of each chosen urban centres in Nigeria obtained from the 1991 population of states by Local Government areas.

$\mathbf{UP_{2030}}$ = The projected population of each chosen urban centre at the end of the master plan sanitation period (year 2030) obtained from the geometric growth rate of a biological community as:

$$\mathbf{UP_{2030} = UP_{1991}\ e^{kt}}$$

Where 'e' is an exponential function.

$\mathbf{SP_{1991}}$ = Population of each states in Nigeria where the urban centres are located as obtained

$\mathbf{SP_{2030}}$ = The projected population of each of the states in Nigeria where the urban centres are located at the master plan sanitation period (year 2030) obtained from the geometric growth rate of a biological community as:

$$\mathbf{SP_{2030} = SP_{1991}\ e^{kt}}$$

$\mathbf{SA_{ha}}$ = The area of each of the states of Nigeria where the urban centres are located in hectares obtained from the Federal Surveys Department.

$\mathbf{UA_{ha}}$ = The area of each of the chosen urban centres in Nigeria in hectares based on the area of the states where the urban centres are located obtained as:

$$\mathbf{UA_{ha} = \frac{UP_{2030}}{SP_{2030}} \times SA_{ha}}$$

The computation of UA_{ha} is based on the assumption that the population of the chosen urban centres are proportional to the urban land use.

$\mathbf{RA_f}$ = The residential area factor (reduction factor) being a percentage of the urban land use for residential purpose as the work excludes industrial sanitation. This is based on historical records of urban land use and on the authors' judgement. Hence, the urban land use for residential purposes ranges from 60% for highly industrialised urban centres to 80% for lowly industrialised urban centres.

$\mathbf{SH_f}$ = Storey height factor (incremental factor) for the population density since most residential buildings in the urban centres of Nigeria are multi storey buildings. This factor is based on the authors' judgement as the author had previously visited all the chosen urban centres. Hence, the storey factor ranges from 200% for highly developed urban centres to 150% for lowly developed urban centres.

$\mathbf{HH_f}$ = Household factor (incremental factor) for the population for the population density computation since the major hypothesis of the study is based on the work of Sinnatamby (1983) in Northeast Brazil. The household factor which accounts for the variations in the size of an household in Nigeria and Brazil is obtained from the state of the world population (1994) published by the United Nations Population Fund as follows:

	Nigeria	Brazil
Urban growth rate (1990-95)	5.5%	2.5%
Fertility rate/women (1990-95)	6.4	2.7
Birth rate per 1000 (1990-95)	45	23

From the preceding data, it could be inferred that the size of an household in Nigeria is approximately twice that of Brazil. Hence the household factor used for the work is 200%.

Table 1. Computation of population density for the chosen urban centres in Nigeria

URBAN CENTRE	k	t	UP_{1991} (persons)	UP_{2030} (persons)	SP_{1991} (persons)	SP_{2030} (persons)	SA_{ha} (hectares)	UA_{ha} (hectares)	RA_f	SH_f	HH_f	PD_{2030}
IKEJA	0.055	39	639,762	5464873.384	5,685,781	48568175.75	344,500	37637.81774	0.6	2	2	967.9756004
ABEOKUTA	0.055	39	374,843	3201924.362	2,338,570	19976161,37	1,676,200	268673.5213	0.7	2	2	68.10016319
AKURE	0.055	39	316,925	2707186.418	3,884,485	33181431.04	2,095,900	170999.0147	0.7	2	2	90.46623283
OSHOGBO	0.055	39	108,892	930159.9541	2,203,016	18818253.51	925,100	45726.39926	0.7	2	2	116.2391927
AJAOKUTA	0.055	39	80,336	686233.4246	2,099,046	17930137.48	2,983,300	114178.7216	0.7	2	2	34.34382344
ILORIN	0.055	39	572,178	4887568.069	1,566,469	13380842.79	3,682,500	1345092.361	0.7	2	2	20.76360049
IBADAN	0.055	39	1,222,590	10443414.19	3,488,789	29801379.5	2,845,400	997124.6716	0.7	2	2	59.8487373
JOS	0.055	39	622,873	5320606.85	3,283,704	28049534.97	5,803,000	1100748.429	0.7	2	2	27.62072324
PORT-HARCOURT	0.055	39	406,783	347457.159	3,983,857	34030270.77	2,185,000	223105.6122	0.7	2	2	88.99711217
SOKOTO	0.055	39	269,525	2302293.664	4,392,391	37519985.04	6,573,500	403361.7653	0.8	1.5	2	21.40411408
JALINGO	0.055	39	137,797	1177067.656	1,480,590	12647260.83	5,447,300	506974.6507	0.8	1.5	2	8.706557031
DAMATURU	0.055	39	162,064	1384357.371	1,411,481	12056928.9	4,550,200	522446.7158	0.8	1.5	2	9.936592543
UMUAHIA	0.055	39	213,630	1824836.269	2,297,978	19629422.83	632,000	58753.46065	0.7	2	2	177.4812191
YOLA	0.055	39	246,099	2102187.806	2,124,049	18143714.14	3,691,700	427731.9771	0.8	1.5	2	18.43024299
UYO	0.055	39	234,615	2004091.004	2,359,736	20156962.21	708,100	70402.3183	0.7	2	2	162.6643712
ANAMBRA	0.055	39	150,357	1284355.694	2,767,903	23643541.56	484,400	26313.39711	0.7	2	2	278.914021
BAUCHI	0.055	39	341,758	29193310.928	4,294,413	36683052.92	6,460,500	514139.5481	0.8	1.5	2	21.29269383
MAKURDI	0.055	39	226,198	1932192.643	2,780,398	23750274.36	3,405,900	277085.4274	0.8	1.5	2	26.14977799
MAIDUGURI	0.055	39	629,486	5377095.368	2,596,589	22180170.31	7,089,800	1718766.367	0.8	1.5	2	11.73173272
CALABAR	0.055	39	320,862	2740816.434	1,865,604	15936066.29	2,015,600	346659.5522	0.8	1.5	2	29.64886317
WARRI	0.055	39	300,720	2568762.64	2,570,181	21954592.08	1,769,800	207072.6754	0.7	2	2	70.88643457
BENIN CITY	0.055	39	780,976	6671129.195	2,159,848	18449510.68	1,780,200	643699.6841	0.7	2	2	59.22130957
ENUGU	0.055	39	465,072	3972664.201	3,161,295	27003912.24	1,283,100	188762.4797	0.7	2	2	120.2619203
IMO	0.055	39	284,931	2433892.351	2,485,499	21231234.95	553,000	63394.45037	0.7	2	2	219.3875995
DUTSE	0.055	39	148,374	126741.826	2,829,929	24173370.21	2,315,400	121397,400	0.8	1.5	2	39.15096237
KADUNA	0.055	39	337,639	2884126.26	3,969,252	33905514.25	4,605,300	391743.5544	0.7	2	2	42.07017908
KANO	0.055	39	403,678	3448234.121	5,632,040	48109117.91	2,013,100	144289.4905	0.7	1.5	2	102.4201152
KATSINA	0.055	39	306,450	2617708.536	3,878,344	33128974.37	2,419,200	191154.7403	0.8	1.5	2	51.35319688
BIRNIN-KEBBI	0.055	39	151,457	1293751.939	2,062,226	17615619.53	3,680,000	270271.9101	0.8	1.5	2	17.95069925
F.C.T. (ABUJA)	0.055	39	378,671	3234623.296	378,671	3234623.296	731,500	731500	0.7	2	2	25.26802692

PD_{2030} = The population density at the end of the master plan sanitation period (year 2030) for each chosen urban centre is obtained as:

$$PD_{2030} = \frac{UP_{2030} \times SH_f \times HH_f}{UA_{ha} \times RA_f}$$

As shown in Table 2: Choice of Appropriate low-cost Sanitation technology for the chosen urban centres in Nigeria'k_w' = Urban water availability growth rate obtained from the data in Nigeria basic health information and housing characteristics as given in the Federal office of statistics yearbook (1996).

'k', the urban water availability growth rate
= <u>% availability in 1993 - % availability in1990</u>

1993 – 1990
= 69% - 63.3% / 3
= 0.02

't_w' = Master plan sanitation period or design period within the framework of water availability is chosen as 1999 to 2030. Hence, based on the level of water service available at the chosen urban centres as at 1990 in Nigeria based on earlier work (Oyebande, 1990) and choosing 30 years as a planning horizon, 't_w', the design period = 40 years

$(\text{Water Availability})_{1990}$ = Level of water service available at the chosen urban centres as at 1990 in Nigeria as extracted from the work of Oyebande (1990) on "Water Supply needs in the 1990's and Strategies for Satisfying them".

$(\text{Water Availability})_{2030}$ = Projected level of water service available for the chosen urban centres in Nigeria at the end of the master plan sanitation period (year 2030) obtained from the geometric growth rate of a biological community as:

$$(\text{Water Availability})_{2030} = (\text{Water Availability})_{1990}\, e^{kw\, tw}$$

Discussion of results

The Appropriate Low – cost sanitation technologies, which gives a principal choice between shallow sewerage systems and on-site sanitation systems is obtained by considering the variables in Table 2. Hence, for population densities lower than 160 persons per hectare, on-site sanitation systems would be a lower cost sanitation technology when compared with shallow sewerage systems while shallow sewerage systems would be favoured for population densities above 160 persons per hectare.

However, (Water Availability)2030, Water availability at the end of the master plan sanitation period (year 2030) for the chosen urban centres in Nigeria is another major factor in the choice of an appropriate low cost sanitation technology. Hence, for shallow sewerage systems, a water availability of not less than 50 litres per persons per day is desirable (Cairncross and Feachem, 1993).

However, on-site sanitation systems is safe for an approximate static (piezometric) water level greater than 1.0m. This is essential to avoid the risk of feacal contamination of groundwater.

Conclusion

The result show that for the chosen urban centres studied in Nigeria (state capitals and key urban centres), 5 out of the 30 urban centres should adopt shallow (simplified) sewerage systems as a lower cost sanitation technology while the remaining 25 urban centres should continue practising the on-site sanitation systems mainly the septic tank and soak aways (22 urban centres) and pour-flush toilets (3 urban centres).

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Table 2. Choice of appropriate low-cost sanitation technology for the chosen urban centres in Nigeria

URBANCENTRE	Kw	tw	PD_{2030} (per;ha)	Water Availability (Per Capita Supply) $_{1990}$ (litres/capita/day)	Water Availability (Per Capita Supply)$_{2030}$ (litres/capita/day)	Approx. Static Water Level (m)	Appropriate Sanitation Technologies	Choice of Appropriate shallow sewerage/on-site Sanitation Systems
IKEJA	0.02	40	968	160	356.0865485	>1.0	Shallow sewerage	Simplified sewerage
ABEOKUTA	0.02	40	68	35	77.89393249	>1.0	On-site sanitation	Septic tanks and soakaways
AKURE	0.02	40	91	32	71.2173097	>1.0	On-site sanitation	Septic tanks and soakaways
OSHOGBO	0.02	40	116	35	77.89393249	>1.0	On-site sanitation	Pour-flsh toilets
AJAOKUTA	0.02	40	34	68	151.3367831	>1.0	On-site sanitation	Septic tanks and soakaways
ILORIN	0.02	40	21	68	151.3367831	>1.0	On-site sanitation	Septic tanks and soakaways
IBADAN	0.02	40	60	51	113.5025873	>1.0	On-site sanitation	Septic tanks and soakaways
JOS	0.02	40	28	80	178.0432743	>1.0	On-site sanitation	Septic tanks and soakaways
PORT-HARCOURT	0.02	40	89	57	126.8558329	>1.0	On-site sanitation	Septic tanks and soakaways
SOKOTO	0.02	40	21	94	209.2008473	>1.0	On-site sanitation	Septic tanks and soakaways
JALINGO	0.02	40	9	18	40.05973671	>1.0	On-site sanitation	Septic tanks and soakaways
DAMATURU	0.02	40	10	18	40.05973671	>1.0	On-site sanitation	Septic tanks and soakaways
UMUAHIA	0.02	40	178	28	62.31514599	>1.0	Shallow Sewerage	Simplified sewerage
YOLA	0.02	40	18	18	40.05973671	>1.0	On-site sanitation	Septic tanks and soakaways
UYO	0.02	40	163	79	175.8177333	>1.0	Shallow sewerage	Simplified sewerage
ANAMBRA	0.02	40	279	62	137.9835375	>1.0	Shallow sewerage	Simplified sewerage
BAUCHI	0.02	40	21	111	247.035043	>1.0	On-site sanitation	Septic tanks and soakaways
MAKURDI	0.02	40	26	254	565.2873958	>1.0	On-site Sanitation	Septic tanks and soakaways
MAIDUGURI	0.02	40	12	76	169.1411105	>1.0	On-site sanitation	Septic tanks and soakaways
CALABAR	0.02	40	30	79	175.8177333	>1.0	On-site sanitation	Septic tanks and soakaways
WARRI	0.02	40	71	67	149.1112422	>1.0	On-site sanitation	Septic tanks and soakaways
BENIN-CITY	0.02	40	59	67	149.1112422	>1.0	On-site sanitation	Septic tanks and soakaways
ENUGU	0.02	40	120	62	137.9835375	>1.0	On-site sanitation	Pour-flush toilets
IMO	0.02	40	219	28	62.31514599	>1.0	Shallow sewerage	Simlified sewerage
DUTSE	0.02	40	39	111	247.035043	>1.0	On-site sanitation	Septic tanks and soakaways
KADUNA	0.02	40	42	123	273.7415342	>1.0	On-site sanitation	Septic tanks and soakaways
KANO	0.02	40	102	113	251.4861249	>1.0	On-site sanitation	Pour-flush toilets
KATSINA	0.02	40	51	113	251.4861249	>1.0	On-site sanitation	Septic tanks and soakaways
BIRNIN-KEBBI	0.02	40	18	111	247.035043	>1.0	On-site sanitation	Septic tanks and soakaways
F.C.T. (ABUJA)	0.02	40	25	192	427.3038582	>1.0	On-site sanitation	Septic tanks and soakaways

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