**WASTEWATER MANAGEMENT IN A DEVELOPING COUNTRY**

**BY**

**ADENIYI OLUWATOBI DAVID – 16/ENG03/055**

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**Abstract**

Affordable and effective domestic wastewater treatment is a critical issue in public health and disease prevention around the world, particularly so in developing countries which often lack the financial and technical resources necessary for proper treatment facilities. This practical guide provides state-of-the-art coverage of methods for domestic wastewater treatment and provides a foundation to the practical design of wastewater treatment and re-use systems. The emphasis is on low-cost, low-energy, low-maintenance, high-performance 'natural' systems that contribute to environmental sustainability by producing effluents that can be safely and profitably used in agriculture for crop irrigation and/or in aquaculture, for fish and aquatic vegetable pond fertilization. Modern design methodologies, with worked design examples, are described for waste stabilization ponds, wastewater storage and treatment reservoirs; constructed wetlands, upflow anaerobic sludge blanket reactors, biofilters, aerated lagoons and oxidation ditches. This book is essential reading for engineers, academics and upper-level and graduate students in engineering, wastewater management and public health, and others interested in sustainable and cost-effective technologies for reducing wastewater-related diseases and environmental damage. Affordable and effective domestic wastewater treatment is a critical issue in public health and disease prevention around the world, particularly so in developing countries which often lack the financial and technical resources necessary for proper treatment facilities. This practical guide provides state-of-the-art coverage of methods for domestic wastewater treatment and provides a foundation to the practical design of wastewater treatment and re-use systems. The emphasis is on low-cost, low-energy, low-maintenance, high-performance 'natural' systems that contribute to environmental sustainability by producing effluents that can be safely and profitably used in agriculture for crop irrigation and/or in aquaculture, for fish and aquatic vegetable pond fertilization. Modern design methodologies, with worked design examples, are described for waste stabilization ponds, wastewater storage and treatment reservoirs; constructed wetlands, upflow anaerobic sludge blanket reactors, biofilters, aerated lagoons and oxidation ditches. This book is essential reading for engineers, academics and upper-level and graduate students in engineering, wastewater management and public health, and others interested in sustainable and cost-effective technologies for reducing wastewater-related diseases and environmental damage.

**Aims and Objectives**

The aim and objective will be treated in order to meet standard for reused and to used appropriate equipment to study or to determine the type of test to be used to treat each characteristic.

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Nigeria is located between Latitudes 4° and 14° N and Longitudes 3° and 15°E on the Gulf of Guinea with a land mass of 923,768 km2, signifying about 14% of the West African landed area (Balarabe et al., 2016). Approximately, 13,000 km2 (1.4%) of the land is covered by water and the remaining 98.6% ranges from thick mangrove forests and dense rainforests in the south to a near-desert condition in the north-eastern part of the country (Ibe and Nymphas, 2010).

Table 1: Agro-ecological zones of Nigeria with some climatic characteristics

|  |  |  |  |
| --- | --- | --- | --- |
| Zone description | Percentage of country area | Annual rainfall (mm) | Monthly temperature (⁰C)Minimum Normal Maximum |
| Semi – arid | 4 | 44 – 600 | 13 | 32 – 33 | 40 |
| Dry sub – humid | 27 | 600 – 1000 | 12 | 21 – 31 | 49 |
| Sub – humid | 26 | 1000 – 1300 | 14 | 23 – 30 | 37 |
| Humid | 21 | 1100 – 1400 | 18 | 26 – 30 | 37 |
| Very humid  | 14 | 1120 – 2000 | 21 | 24 – 28 | 37 |
| Ultra humid (flood) | 2 | >2000 | 23 | 25 – 28 | 33 |
| Mountainous | 4 | 1400 – 2000 | 5 | 14 – 29 | 32 |
| Plateau | 2 | 1400 – 1500 | 14 | 20 -24 | 36 |

Additionally, the country has a coastline of over 853 km with about 80% in the Niger Delta region. The country is adjoined by four countries including the Republic of Benin in the West, Niger and Chad Republic in the North, the Cameroon Republic in the East, while the Atlantic Ocean forms the southern limits of the territory (FAO-Aquastat, 2016). There are three distinct ecological zones in the country including Guinea savannah, Northern Sudan savannah and Southern rainforest (Cosmas et al., 2010). However, the agro-ecological zones, governed by the combined effects of rainfall variations, soil, humidity, and temperature, are divided into eight zones for the purpose of irrigation practice (Table 1).

The climate in Nigeria is characterized by relatively high temperature and variations in the amount of precipitation throughout the year with alternating two seasons (rainy and dry) (Ibe and Nymphas, 2010). The rainy season is generally from April to October and the dry season from November to March, with some degrees of spatial and temporal variations in the amount and distribution of rainfall across the agro-ecological zones (Akande et al., 2017; Bibi et al., 2014). The southern part of the country has the highest average annual rainfall, ranging from 1524 to 2035 mm with duration of eight to nine months. The middle belt ranges from 508 to 1524 mm while it is less than 508 mm annually for a period of five to six months in the north and less than four months in the far north (Oriola and Alabi, 2014).

Furthermore, a short dry season is known as “August break” generally comes up in the month of August. The dry season persists from late October to early March. This period witnesses dusty north-east winds (Chineke et al., 2010). However, the Northern Nigeria which experiences short wet season, the dry season is very long, from October to mid-May. Annually, the average temperature ranges from 21 to 32°C in the south while the north has a temperature range of 13 to 41°C. Nigeria, the most populous country in Africa, was estimated to have a population of over 140 million in 2006 and the United Nation estimate in 2015 was roughly 181 million (United Nations, 2017). However, the exponential projection growth in the population has not translated to food sufficiency but rather the agricultural production is on the decline. There is an uneven spatial population distribution with about 65% living in rural areas and the rest in urban areas (Aidi et al., 2016). The major occupation of people in rural areas is agriculture but with a low level of productivity (Dayo et al., 2009). The level of food insecurity in the rural areas of Nigeria is alarming with 84.3 % reported in some communities in the north and about 56% in the south west of the country (Akinyele, 2009). The country relies mostly on the importation of agricultural produce to feed its growing population in spite of her production potential in agriculture. The only way out to address the challenges of food insecurity and rural poverty is to find the solution to agricultural production in the country (Xie et al., 2017).

In Nigeria, agriculture remains the bedrock of the economy as it provides a living for the majority of its populace. World Bank (World Bank, 2014) reported that the agricultural sector alone accounts for 33% of the total GDP of Nigeria and the sector employs around 23% of the total economically active population (FAO, 2014). Agriculture used to be the Nigerian major source of foreign exchange from independence in 1960 up to the mid-1970s when Nigeria was the world‟s largest producer of groundnuts, palm oil, and cocoa, and one of the major producers of millet, maize, yam, cassava, coconuts, citrus fruits and sugar cane (Ladan, 2014). However, the sector has been on the neglect and contributed less economically since the early 1970s when attention was shifted to oil revenues. Notwithstanding the reliance of the country‟s economy on proceeds from oil export, Nigeria remains agrarian with her endowed substantial natural resources including 68 million hectare of arable land, abundant freshwater resourcess covering about 12 million hactare, and an ecological diversity which enables the country to produce a wide variety of crops and livestock, forestry and fisheries products (Arokoyo, 2012). Moreover, the dry northern savannah is appropriate for sorghum, millet, maize, groundnuts, and cotton while cassava, yam, plantain, maize, and sorghum can successfully be grown in the Middle Belt. Cash crops like oil palm, cocoa and rubber can be grown in the South whereas low-lying and seasonal flooded areas can grow rice (FAO-Aquastat, 2016). The government has acknowledged the need to diversify the country‟s economy by giving adequate attention and promoting the development of the agricultural sector in order to shift from a mono-cultural economy of oil exports (Olajide et al., 2012).

Farming system in Nigeria can still be regarded as subsistence-based and it is predominantly rainfed, which makes it overly dependent on weather fluctuations. The irrigated agriculture only accounts for one percent of the cultivated area (FAO-Aquastat, 2017). Many farmers are out of jobs during the dry season and local food prices are on the rise as a result of food scarcity during this period. However, the green revolution requires all-year-round farming. The role of irrigation cannot be ignored as it is the only way to achieve the mandate of “Green Alternative” of the present administration. Hence, there is a need to evaluate the irrigation practices in the country so as to know what has been done in the past, the present status, and how to improve for the future developments.

**Literature Review**

**Wastewater Management**

Wastewater management in developing countries throughout the world is in a state of crisis. It is estimated that 2.6 billion people worldwide live without adequate sanitation. Resources are scarce, previous management systems have failed, and traditional techniques and solutions are not immediate enough, too expensive, or simply inefficient. This book investigates the complex political, economic, and cultural reasons that so many developing nations lack the ability to provide proper and effective wastewater treatment for their citizens.

The authors draw upon their experiences in Malaysia, Thailand, and other countries to inspire innovation and improvement in wastewater treatment and management. They examine the failures of traditional planning, design, and implementation, and offer localized solutions that will yield effective sustainable management systems. These solutions include reuse of treated wastewater, energy conservation, and proper financial and organizational set up. Sustainable Wastewater Management in Developing Countries will urge practitioners, decision makers, and researchers to approach these systems in new ways that are practical, innovative, and—best of all—sustainable.Surface and subsurface water flows are changing due to changes in land use in Nigeria. Important changes are due to agriculture itself especially logging, urbanization and development of infrastructure. Population growth also reduce the per capita availability of fresh water supplies leading to stress and even scarcity. Under a new classification scheme, a country with an annual renewable fresh water supply per capita of more than 1,700 m3 will experience only occasional local water shortages. On the other hand, a country having an annual supply of less than 1,000 m3 per capita will experience chronic water shortages leading to serious environmental problems [1]. Although, Nigeria has sufficient water potential to meet the 2025 requirement, serious efforts have to be made to develop water sources to do so.

The water resources potential of Nigeria is estimated to be 250 x 109 m3, comprising 190 x 109 m3 of surface water with the balance in form of groundwater. This not withstanding, water is still a limiting factor to agriculture in much of the country but most especially, in the northern semi-arid and dry sub-humid zones lying above latitude 110 N. According to Adedeji (2008) [16], there are a total of 149 dams in the country. Out of these, 81 are owned by State governments, 59 by the Federal government and 9 belong to private companies. There are 107 large dams out of which 59 are principally for irrigation whereas 20 are for hydropower. Of the 34 small and medium dams in the country, only 15 are for irrigation purposes.

As a result of the FAO and US Bureau of Reclamation studies conducted in the early 1970s, three pilot public irrigation schemes were developed all in the sub-arid and dry sub-humid agro-ecological zones, namely: Bakolori scheme, the Kano River Irrigation scheme and the Chad Basin scheme. The success of these pilot schemes coupled with five year drought between 1970 and 1975 led to the establishment of eleven (11) River Basin Development Authorities (RBDAs) in the country (see Table 3). Development of drainage systems and improved water management practices could return large areas to productive use especially in the RBDAs where there are still huge potentials since irrigated areas constitute 31.6% of actually equipped area.

**Anaerobic technology for wastewater treatment**

Answering to the high priority request concerning the sustainability criteria of the wastewater treatment technology, the anaerobic wastewater treatment should be regarded as the core method of a sustainable wastewater management strategy due to its benefits and enormous potentials such as: Little (if any) use of mineral resources and energy; Enabling production of resources/ energy from wastes; Pairing high efficiency with long term of lives; Applicable at any place and at any scale; Plain in construction, operation and maintenance. Moreover, although conventional aerobic treatment systems generally provide excellent treatment efficiency, they do not fully meet the criteria needed for a sustainable wastewater management strategy.

**Application of anaerobic technology**

Nowadays, the anaerobic technology has a very wide application in the field of anaerobic digestion whether for liquid or bio-solid waste. The system that shows the main overall application of the anaerobic digestion.

**Benefits and drawbacks of anaerobic municipal wastewater treatment**

Based on the past experiences and learned lessons in the municipal wastewater treatment, the anaerobic technology proved a very good performance and efficiencies due to its positive advantages against aerobic ones. The main advantages of anaerobic over aerobic treatment are in detail:

 1. Instead of using 1 kWh of electricity, 1 kWh of electricity can be produced • Positive, instead of negative energy balance

2. Lower sludge production is between 0.02 and 0.2 kg/kg COD-eliminated instead of 0.3 – 0.5 kg/kg COD-eliminated. • Lower secondary costs for sludge dewatering, transport and disposal/use 3. Higher volumetric reactor loading rates • 3 – 15 kg COD/(m3 reactor.d) instead of 0.3 – 1 kg/(m3.d) 4. Nutrients are not removed and remain available.

Moreover, the technologies are simple in construction, operation, monitoring, and maintenance, consequently they are cost-effective technologies. Also the systems can be applied everywhere and at any scale and working with high treatment efficiencies.

**Conclusion**

Currently there is a growing awareness of the impact of sewage contamination on rivers and lakes; therefore, wastewater treatment, water and wastewater fees and environmental education according to water saving is now receiving greater attention from a lot of international organizations and government regulatory bodies. However, the waste water treatment systems in developing countries are not successful and therefore unsustainable because they were simply copied from Western treatment systems without considering the appropriateness of the technology for the culture, land, and climate. Often local engineers educated in the Western development programs supported the choice for the inappropriate systems. Many of the implemented installations were abandoned due to the high cost of running the system and repairs.

**Recommendations**

There would be need to develop low cost water and soil conservation technologies, which include improved water harvesting in the areas with high rainfall, soil tillage, mulching, terracing etc in order to close the food supply gap in the country.

There is an urgent need to improve the traditional irrigation schemes for application in the production of staple food crops, notably rice, vegetables and tuber crops. In order to achieve her food security targets, the country must introduce the use of small farmer owned sprinkler systems which could assist in boosting cash crops production.

The need has to shift emphasis towards rehabilitation and modernization of existing irrigation systems, but the cycle of construction-deterioration-rehabilitation has to be broken through greater mobilization of resources from the farmers to ensure adequate operation and maintenance. Dung out ponds and earth dams should be exploited by local governments for rainwater harvesting in high rainfall areas for dry season farming.

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