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Strategy for Remediating the Impacts of Solid Wastes on Soil and Groundwater Quality in Minna, Nigeria *(pp.173-184)*

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Abstract: The current status of solid waste management in Minna has been reviewed and recommendations for improvements are made. The existing solid waste management system is affected by unfavourable economic, institutional, legislative, technical and operational constraints. A reliable waste collection service is needed and waste collection vehicles need to be appropriate to local conditions. More vehicles are required to cope with increasing waste generation. Wastes need to be sorted at source as much as possible, to reduce the amount requiring disposal. Co-operation among communities, the informal sector, the formal waste collectors and the authorities is necessary if recycling rates are to increase. Markets for recycled materials need to be encouraged. Despite recent improvements in the operation of the existing dumpsite, a properly sited engineered landfill should be constructed with operation contracted to the private sector. Wastes dumped along roads, underneath bridges, in culverts and in drainage channels need to be cleared. Small-scale waste composting plants could promote employment, income generation and poverty alleviation. Enforcement of waste management legislation and a proper policy and planning framework for waste management are required. The mean per capital generation rate for the study areas ranges from 0.513 to 0.515 kg/cap/day. Accurate population and generated waste data should be kept for future planning. Leachates influx through the soil affects groundwater quality. Funding and affordability remain major constraints and challenges.

Key words: strategies, remediating, solid waste, soils, groundwater quality

1 INTRODUCTION

Waste is regarded as any environmental pollutant that is caused by human induced activities or through natural phenomena. This condition often upset the natural balance of the ecosystem. Waste irrespective of its source may be categorized as either organic or inorganic out-valued material to the generator, which is commonly disposed of. The generation of waste material is known as the waste stream. This includes the entire variety of refuse generated during domestic, industrial, construction and commercial processes.

It is fifty decades now when Nigeria became a sovereign nation. Despite this, the general concept about the importance of environmental protection through awareness and orientation is still heedless. Nigeria being a developing nation has 75 percent of its

population not able to willingly draw a connection between the need to protect the environment and what each individual can do to save it. When people are asked to sort household refuse for recycling and proper disposal onto farms or pay a fee to discharge it from their homes and streets, endless excuses often results.

The improper disposal and treatment of solid waste is one of the greatest environmental treat of the 21st Century. The impact of these wastes on soil and groundwater quality can be devastating, depending on the composition of the heterogeneous mixture and method of disposal. The generation of waste is a function of human activities; therefore, proper waste disposal has become steadily imperative with no compromise if only a healthy society and generation is to be achieved.

Municipal refuse is the litter originating from urban areas; this comprise of waste due to domestic, commercial, institutional, construction, agricultural or mining activities.
Indiscriminate disposal of wastes naturally proliferate the tendency of attracting flies, rodents, cats, dogs, mosquitoes, unpleasant smell, as well as creation of unsanitary conditions and other aesthetic problems resulting from open dumpsites. Agricultural soils exposed to incessant deposition of solid waste are liable to become contaminated due to influx of heavy metals, which subsequently through intrusion intercept and affect the groundwater quality.

2 REVIEW OF RELEVANT LITERATURE

Solid waste includes any garbage, refuse, sludge and items that that have lost its original value, hence discarded or getting ready to be discarded (United State Environmental Protection Agency,USEPA, 2000). Items considered as waste are household rubbish, sewage sludge, from manufacturing processes, packaging materials, discarded cars, old electronics, garden waste, old paint containers etc. (Salvato, 1992).
The move from landfill-based to resource-based waste management systems requires a greater knowledge of the composition of municipal solid waste (Stephen, 2006). Solid waste in Nigeria is generally composed of three categories i.e. biodegradable such as food waste, animal waste, leaves, grass, straws, and wood. Non-biodegradable are plastic, rubber, textile waste, metals, glass and recyclables such as paper, cardboard, rags and plastics. Solid waste generation and management differ considerably in cities of developed countries to that of developing cities. Reason for this may be attributed to the cost of purchasing and maintaining haulage trucks, bunkers and waste bins is pretty high.



Figure 1: Solid waste accumulated at temporary storage bin

One of the consequences of the global urbanization is increasing volumes of solid waste generation. According to estimates about 1.3 billion metric tons of municipal solid waste was generated globally in 1990 (Beede & Bloom, 1995). At present, the yearly generation of solid waste equals to 1.6 billion metric tons approximately (United State Environmental Protection Agency USEPA). A considerable amount of money goes into managing such huge volumes of solid waste. Asian countries alone spent about US$25 billion on solid waste management per year in the early 1990s; the figure is expected to rise to around US$50 billion by 2025 (Hoornweg and Thomas, 1999). These figures suggest that solid waste management has become a large, complex and costly service. Solid Waste Management is a discipline associated with the control of generation, storage, collection, transfer, processing and disposal of Municipal Solid Waste.

Municipal solid waste, in a way is governed by the best principles of public health, economics, engineering, aesthetics and other environmental considerations (Daskalopoulos et al., 1999). The municipalities in developing countries typically lack the financial resources and skills needed to cope with this crisis. Several countries have realized that the way they manage their solid wastes does not satisfy the objectives of sustainable development (Abu Qdais, 2006). This raises the important issue of how to deliver quality service in the face of the financial and skill constraints of the public sector. (Mansoor and Azam, 2006).

The developing world can expect a significant increase in its waste stream. In India, reuse and recycling was the trend, but systems are now stretched beyond their carrying capacities. Almitra H. Patel claims that up to 15 years ago the bulk of city waste was carted to farms for composting. However, the influx of plastics, particularly thin-film carrier bags, which precludes germination of plants and the entry of rainwater into the soil, has been a major deterrent to the rural use of municipal waste, which now ends up in open dumps outside

cities and towns. Patel asserts that plastic is the scourge in India's landscapes; wind-blown thin-film carrier bags are visible everywhere. They contribute to flooding where they block drains, and kill livestock that forage in the streets eating garbage-filled plastic bags that remain undigested. Following globalization, Indian cities have been inundated with packaging that is recyclable, but is not in practice recycled; consequently, cash strapped municipalities are battling with large heaps of nuisance wastes, Patel added.

South Africa, a country slowly emerging from a period of non sustainable and inequitable development, the likes of which has not only had significant economic and social impacts, but has also resulted in serious environmental degradation, its National Waste Management strategy (NWMS) and Action Plans were finalized in 1999. In September 2001, representatives of the national, provincial and local governments, civil society and the business community convened at Polokwane-the Northern Province for discussions over the existing waste management situation in South Africa. Following this, a joint declaration was delivered with specific aims to implement a waste management system that contributes to sustainable development and safeguarding livelihoods, by harnessing the energy and commitment of citizens to waste reduction. The joint declaration also proposed the reduction of waste generation by 50 per cent and disposal by 25 per cent respectively by 2012 as well as developing a plan for zero waste by 2022. Further reference was made to reiterate a commitment to the Integrated Pollution and Waste Management (IPWM) Policy, the NWMS and the principles of waste minimization, reuse and recycling for sustainable development.

A World Bank report states that 19,000 tonnes of hazardous wastes are produced annually in this country. The report further states that 99 percent of this figure is produced by six industrial sectors, namely; steel, metal fabrication, textiles, pharmaceuticals, tanning, and oil refining (Anthony, 2000). There is an increase in the nation's health problems and increase in the incidence of typhoid fever.

Nigeria and South Africa are spearheading the New Partnership for African Development (NEPAD); the initiatives proposed might be great for Africa if acted upon. However, for many living in Lagos and Aba whereby waste disposal remains a contentious issue, refuse is thrown onto roadways, spread on pedestrian walkways or even dumped into gutters. The problem becomes compounded during the rainy season; water, no longer flowing freely along the gutters it remains stagnant, creating the necessary conditions for mosquitoes and vector borne diseases like malaria. It situation became so unpleasing that a pragmatist approach was adopted requiring residents to spend the last Saturday of the month for cleaning up refuse placed on the streets.

3 MATERIALS AND METHODS

3.1 Description of the Study Area

Minna, the Niger State capital has an average maximum temperature of 37^{o}C and average minimum of 21^{o}C. Minna is generally humid with two distinct weather which are, dry season (November to February) and raining season that lasts from March to October. The

rainfall distribution pattern of the city and its environs is unimodal, annual rainfall ranges from 1000mm to 1200mm respectively (NIMET, 2009). The topography of the soil is undulating and rich in organic matter contents. The vegetation consists of mixed leguminous (guinea) woodland to forest savannah and wide expanse of wetland for Fadama farming. The city lies between latitude 9^{o} 30'N and longitude 6^{o} 25'E. It covers a total landmass of approximately 1300 sq. km (Adeniyi, 1985). It is situated in the Guinea savanna belt. The city is cosmopolitan in nature with hives of socio-economic activities.

3.2 Methodology

To obtain the required data and information, the study was conducted between February and April 2010. Investigative Survey Research Approach (ISRA) was adopted in carrying out the study. However, to facilitate the sampling procedure, Minna the study area was divided into 2 two groups based on the classification provided by the municipal planning authority, thus; low and high-density areas. Furthermore, Twenty (20) houses were randomly selected from the two groups, taking into consideration low and high-income households.

In total, 20 houses were surveyed with a 99.5% response rate. The households were requested to put their waste in the provided waste bins, which are collected and weighed. This process was repeated for two weekends each. The weighing was conducted with the use of a weighing balance while accurate data was recorded for each household.

4 RESULTS AND DISCUSSION

Wastes are collected in bags for measurements as in figure 1,



Figure 2: Solid Waste Collected in Sacks for Measurement

The the solid waste generation rates were determined as presented in table 1 and 2

Table 1: **Data from the highly populated area of Minna (Anguwan Daji layout)**

S/N	No of Occupants	Weight of Solid Waste (kg)	per Capital Generation (kg/cap/day)
1	15	08	0.53
2	12	6.2	0.52
3	23	12	0.52
4	08	4.5	0.56
5	11	06	0.54
6	08	3.6	0.45
7	15	7.4	0.49
8	12	6.1	0.51
9	17	8.2	0.48
10	14	7.3	0.52

The mean per capital generation rate for this area **is estimated as 0.513kg/cap/day**

Table 2: **Data obtained from the study on the low populated area of Minna (Dutsen Kura)**

S/N	No of Occupants	Weight of Solid Waste (kg)	per Capital Generation (kg/cap/day)
1	07	3.9	0.56
2	05	2.6	0.52
3	05	2.2	0.44
4	06	3.2	0.53
5	04	1.9	0.48
6	06	3.3	0.55
7	07	3.6	0.51
8	05	2.6	0.52
9	06	3.2	0.53
10	04	2.0	0.50

The mean per capital generation rate for this area **is estimated as 0.515kg/cap/day**
It is observed that the generation rate of the two areas under consideration varies slightly. Therefore the range falls between (**0.513-0.515**)kg/cap/day.
The most prominent groundwater quality problem within the study sites is relatively high iron concentrations. A few tens of Shallow aquifers equipped with hand pumps have been rejected by rural population on the account of colouration effect of the water on cooking utensils, plastic or metal buckets as well as the foodstuffs which are cooked with such water. There is therefore, the need to incorporate some simple iron removal plants through which iron contaminated water from the outlets of the hand pumps can flow to render the

water acceptable for domestic use. Consequently, if such water is allowed to remain in the same container for about 3-4 days emergence of maggots becomes visible.



Figure 3: Leachate Proliferation

5 STRATEGIES FOR REMEDIATING THE ADVERSE EFFECTS OF SOLID WASTE ON AGRICULTURAL SOILS AND GROUNDWATER

Principal strategies for soil remediation are outlined as:

- excavating soil and taking it to a disposal site away from ready pathways for human or sensitive ecosystem contact,
- aeration of soils at the contaminated site,
- thermal remediation by introduction of heat to raise subsurface temperatures sufficiently high to volatize chemical contaminants out of the soil for vapour extraction,
- extraction of groundwater or soil vapour with an active electromechanical system, with subsequent stripping of the contaminants from the extract,
- containment of the soil contaminants (such as by capping or paving over in place),

Phyto-remediation, or using plants (such as willow) to extract heavy metals.

6 CONCLUSSION

The recommendations of this study are in line with the compliance criteria of table 3

Table 3: **Management of Municipal Solid Wastes for Minna Metropolitan**

S/N	Parameters	Compliance criteria
1.	**Collection of municipal solid wastes**	1. Littering of municipal solid waste shall be prohibited in cities, towns and in urban areas notified by the State Governments. To prohibit littering and facilitate compliance, the following steps shall

2.	Segregation of municipal solid wastes	be taken by the municipal authority, namely :- i. Organizing house-to-house collection of municipal solid wastes through any of the methods, like community bin collection (central bin), house-to-house collection, collection on regular pre-informed timings and scheduling by using bell ringing of musical vehicle (without exceeding permissible noise levels); ii. Devising collection of waste from slums and squatter areas or localities including hotels, restaurants, office complexes and commercial areas; iii. Wastes from slaughter houses, meat and fish markets, fruits and vegetable markets, which are biodegradable in nature, shall be managed to make use of such wastes; iv. Bio-medical wastes and industrial wastes shall not be mixed with municipal solid wastes and such wastes shall follow the rules separately specified for the purpose; v. Collected waste from residential and other areas shall be transferred to community bin by hand-driven container carts or other small vehicles; vi. Horticlutural and construction or demolition wastes or debris shall be separately collected and disposed off following proper norms. Similarly, wastes generated at dairies shall be regulated in accordance with the State laws; vii. Waste (garbage, dry leaves) shall not be burnt; viii. Stray animals shall not be allowed to move around waste storage facilities or at any other place in the city or town and shall be managed in accordance with the State laws. 2. The municipal authority shall notify waste collection schedule and the likely method to be adopted for public benefit in a city or town. 3. It shall be the responsibility of generator of wastes to avoid littering and ensure delivery of wastes in accordance with the collection and segregation system to be notified by the municipal authority. In order to encourage the citizens, municipal authority shall organise awareness programmes for segregation of wastes and shall promote recycling or reuse of segregated materials. The municipal authority shall undertake phased programme to ensure community participation in waste segregation. For this purpose, regular meetings at quarterly intervals shall be arranged by the municipal authorities with representatives of local resident welfare associations and non-governmental organizations.

S/N	Parameters	Compliance criteria
3.	**Storage of municipal solid wastes**	Municipal authorities shall establish and maintain storage facilities in such a manner as they do not create unhygienic and insanitary conditions around it. Following criteria shall be taken into account while establishing and maintaining storage facilities, namely :- i. Storage facilities shall be created and established by taking into account quantities of waste generation in a given area and the population densities. A storage facility shall be so placed that it is accessible to users; ii. Storage facilities to be set up by municipal authorities or any other agency shall be so designed that wastes stored are not exposed to open atmosphere and shall be aesthetically acceptable and user-friendly; iii. Storage facilities or 'bins' shall have 'easy to operate' design for handling, transfer and transportation of waste. Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black; iv. Manual handling of waste shall be prohibited. If unavoidable due to constraints, manual handling shall be carried out under proper precaution with due care for safety of workers.
4.	**Transportation of municipal solid wastes**	Vehicles used for transportation of wastes shall be covered. Waste should not be visible to public, nor exposed to open environment preventing their scattering. The following criteria shall be met, namely:- i. The storage facilities set up by municipal authorities shall be daily attended for clearing of wastes. The bins or containers wherever placed shall be cleaned before they start overflowing; ii. Transportation vehicles shall be so designed that multiple handling of wastes, prior to final disposal, is avoided.
2.	**Segregation of municipal solid wastes**	In order to encourage the citizens, municipal authority shall organise awareness programmes for segregation of wastes and shall promote recycling or reuse of segregated materials. The municipal authority shall undertake phased programme to ensure community participation in waste segregation. For this purpose, regular meetings at quarterly intervals shall be

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5.	**Processing of municipal solid wastes**	Municipal authorities shall adopt suitable technology or combination of such technologies to make use of wastes so as to minimize burden on landfill. Following criteria shall be adopted, namely:-

		(i) The biodegradable wastes shall be processed by composting, vermicomposting, anaerobic digestion or any other appropriate biological processing for stabilization of wastes. It shall be ensured that compost or any other end product shall comply with standards as specified. ii. Mixed waste containing recoverable resources shall follow the route of recycling. Incineration with or without energy recovery including pelletization can also be used for processing wastes in specific cases. Municipal authority or the operator of a facility wishing to use other state-of-the-art technologies shall approach the Central Pollution Control Board to get the standards laid down before applying for grant of authorization.
6.	**Disposal of municipal solid wastes**	Land filling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing. Land filling shall also be carried out for residues of waste processing facilities as well as pre-processing rejects from waste processing facilities. Land filling of mixed waste shall be avoided unless the same is found unsuitable for waste processing. Under unavoidable circumstances or till installation of alternate facilities, land-filling shall be done following proper norms. Landfill sites shall meet the regulatory agency specifications.

Unless citizens are fully involved and committed, no amount of capital injected into waste management would suffice. To this end, television and radio stations can be helpful in offering free airtime while print media could run waste management and recycling columns.

i. People from the affected population are involved in the design and implementation of the solid waste programme.
ii. Household waste is put in containers daily for regular collection, burnt or buried in a specified refuse pit.
iii. All households have access to a refuse container and/or are no more than 100 metres from a communal refuse pit.
iv. At least one 100-litre refuse container is available per 10 families, where domestic refuse is not buried on-site.
v. Refuse is removed from the settlement before it becomes a nuisance or a health risk.
vi. Medical wastes are separated and disposed of separately and there is a correctly designed, constructed and operated pit, or incinerator with a deep ash pit, within the boundaries of each health facility.

vii. There should be a clearly marked spots for refuse pits, bins or specified areas at public places, such as markets and slaughtering areas, with a regular collection system in place.
viii. Final disposal of solid waste is carried out in such a place and in such a way as to avoid creating health and environmental problems for the local and affected populations.

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