

**GIS-BASED ASSESSMENT OF THE POTENTIAL RISK
OF LANDFILL SITES ON THEIR SURROUNDING
ENVIRONMENT USING ABA-EKU LANDFILL
SITE-IBADAN AS A CASE STUDY**

**OCENA POTENCJALNEGO ZAGROŻENIA
WYSYPISK ŚMIECI DLA ŚRODOWISKA W ICH OKOLICY
Z WYKORZYSTANIEM GIS NA PRZYKŁADZIE
WYSYPISKA ABA-EKU W MIEŚCIE IBADAN**

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Słowa kluczowe: GIS, wysypisko śmieci, odpady stałe, ArcGIS 9.1

Introduction

Solid waste problems already top the issues confronting the urban dwellers and planners in Nigeria today. There is arbitrary dumping of waste along roads, open space, drainages and canals. Improper storage, handling, transportation, treatment, and disposal of hazardous wastes results in an adverse impact on the ecosystem including the human environment.

The management of solid waste is poor and has become a monumental challenge in Ibadan city, with unprecedented growth of the city and a population density which is among the highest in the country. The problem is aggravated by the open dump nature of waste disposal in almost every part of the city, with no provision for proper Sanitary Landfill for final disposal.

Site survey has shown that these open dump sites do not conform to the simple definition of landfill site. Rather, wastes are disposed in an unsatisfactory manner with little regard for pollution control or aesthetics. These so-called landfills are mere dumps without proper liners and leachate collection systems. Each layer of garbage is supposed to be lined with mud, but this is often not done. Many of the landfills are located over groundwater aquifers near surface water and residential areas, and since natural depressions are selected while creating landfills, the garbage is even closer to the groundwater.

Ibadan Metropolis has four functional dump sites. Most of these dumps are near small towns and communities; in most cases little or nothing is known about the health or environmental impacts of these dumps on their surrounding environment and people.

The purpose of this study is to assess the potential risk of waste dump sites on their surrounding environment, with Aba-Eku dumpsite, Ona-Ara L.G.A as the case study. This research study hopes to provide clearer picture about the health, environmental and economic impacts of these dumps and the role the board in charge of waste management should play in investigating and reducing risks at dump sites.

Aim

The aim of this study is to use GIS to assess the potential risk of landfill sites on their surrounding environment using Aba-Eku landfill site as a case study.

The existing situation of the study area

Ibadan Waste Management Board Authority operates four function landfill sites, some of which date back to the early 60s. The most widely used of these sites is the Aba-Eku dumpsite, which is located at the outskirts of the city of Ibadan, along the Akanran Road. The operators of this site (frequently Ibadan Waste Management Board Authority and private contractors) accept an uncontrolled mix of commercial, industrial, biomedical, household waste and construction debris and dump them on this site without sorting or treatment. This equates to open dumping of wastes of diverse composition ranging from household wastes which include disposable nappies soiled with faeces, domestic waste may also contain blood stained materials such as sanitary pads, tampons and discarded wound dressings; animal wastes; in-organic wastes; agricultural wastes; and semi-liquid material comprising sewage sludge, slaughter house waste etc.

Wastes are being dumped on this mass of land on a daily basis in a crude and unscientific manner. Earth moving tractors come to push waste further inwards; the site is occasionally fumigated and refuse are often burnt to reduce the volume. No provision is made for the recording and filling of volume and weight of wastes, types, density and composition of waste. The site also hosts scavengers picking useful junk and domestic animals were also found eating food remnants.

Ideally, a landfill site should be 3 kilometres away from a residential land-use and at least 1.5 km away from water bodies, but at this site houses have been built even up to site fence lines and almost all these buildings have their own well close by.

The Aba-Eku Landfill site covers a total area of 25 acres (about 10 hectares); it is defined by Longitude $3^{\circ}59'E$ and $3^{\circ}91'E$ and Latitude $7^{\circ}19'N$ and $7^{\circ}22'N$. It falls in the periphery of Ibadan and along the Akanran road, Ona-Ara L.G.A. (Fig. 1).

Data analysis and results

ArcGIS 9.1 installed on the department laboratory was used for geo-referencing the analogue map, data conversion, data manipulation and analysis.

The following data were used for the analysis in this study: drainage map comprising rivers and streams; land use map recording built-up areas, agricultural land use and institutional land use of the area.

Based on the literature and the United States Environmental Protection Agency (U.S. EPA) standard for site selection, criteria were specified to assume that the site would be outside the buffer zones of water bodies, built-up areas, institutional and agricultural land uses.

These were as follows (Source: Ahmad Al-Hanbali, Chiba University):

- at least 3 km away from built-up areas,
- at least 2 km away from water bodies,
- at least 1 km from agricultural land use,
- at least 1 km way from institutions,
- at least should not be more than 500 m away from major roads.

Analysis

A buffer of 3km was created around the landfill site as shown in Figure 2 and it was overlaid on the built-up area layer, to check whether there are built-up settlements that fall within that buffer zone. The result showed that a total of fifteen settlements fell within this zone (see Fig. 2) and may be exposed to the hazardous elements.

For the water bodies, the site should be at least 1.5 km away from water bodies of both underground and surface water. A buffer of 1.5 km was created around the landfill site and overlay of the drainage map showed that two main rivers fell within the buffer zone. It was noticed during field work that almost all the buildings around the landfill site have their privately constructed well for drinking water. Since many wells fell within the 1.5 km buffer, both surface and underground water around the site are at high risk of being polluted.

Agricultural land use should be at least a kilometer away from the landfill site. A buffer of 1 km was created round the site and overlaid on the agricultural land use layer. The result showed that about 80% farmland fell within this buffer zone.

A buffer of 1km was created round the site and also overlaid on the institutional land use layer, so as to check whether there are schools that fall in the buffer zone. A total number of 6 schools (both primary and secondary) fell in the 1km buffer zone.

Soil and water sampling results

Soil and water sampling gave a better understanding of the type of waste that had been disposed of and the level of contaminants in the samples (Table 1, Fig. 3). A total number of thirteen elements were tested for in the soil and water samples, and for pH and conductivity. All the elements tested for in the samples were detected; some were found to be at levels above the permitted standard. The results of the water analyses are shown in Table 2 and the soil results in Table 3.

Table 1. Proposed Sampling Locations

Code	Longitude	Latitude	Description
S1	4°0'7.902"	7°18'10.0902"	Soil Sample
S2	3°59'30.6342"	7°18'9.5004"	Soil Sample
S3	4°0'36.3702"	7°19'4.4688"	Soil Sample
S4	4°1'33.4338"	7°18'7.4046"	Soil Sample
W1	4°0'40.4346"	7°18'5.9502"	Water Sample
W2	4°0'55.2276"	7°18'44.9922"	Water Sample

Table 3. Summary of Soil Analysis and Mean Standards

Parameters	Standards (ppm)	Result	Remarks
Calcium	Not Available	42.390	–
Magnesium	Not Available	7.880	–
Potassium	Not Available	0.569	–
Sodium	Not Available	135.18	–
Manganese	Not Available	272.00	–
Copper	10	22.070	APL
Iron	35	221.7	APL
Lead	85	0.110	BPL
Nickel	35	0.15	BPL
Chromium	10	0.12	BPL
Cobalt	20	0.07	BPL
Cadmium	0.8	0.03	BPL
Zinc	140	511.650	APL

Source: Field Survey, 2007

APL – Above Permitted Level, BPL – Below Permitted Level

Table 2. Summary of Water Analysis and Water Standards

Parameters	WHO Standards (ppm)	Result	Remarks
Calcium	75	35.630	BPL
Magnesium	50	21.890	BPL
Potassium	10	18.664	APL
Sodium	150	11.390	BPL
Manganese	0.5	5.66	APL
Copper	2	0.330	BPL
Iron	0.2	1.76	APL
Lead	0.01	0.04	APL
Nickel	0.02	0.07	APL
Chromium	0.05	0.03	BPL
Cobalt	0.02	0.01	BPL
Cadmium	0.003	0.00	BPL
Zinc	3	0.810	BPL
Conductivity	250	950	APL
pH	6.5	6.5	PL

Source: Field Survey, 2007

APL – Above Permitted Level, BPL – Below Permitted Level,
PL – Permitted Level

Discussion

Based on the laboratory tests carried out on the water and soil samples collected on and around the dump, the Aba-Eku landfill site was contaminated with hazardous elements, e.g. Lead, Nickel, Copper, Zinc, Manganese, Iron etc, and contains physical harmful materials (scrap metals, surface debris). High levels of Iron, Lead, Nickel, Manganese etc were found in the tested drinking water, which has great health implications as these elements cause diverse diseases and infections, including cancer, respiratory failure, pneumonia, conjunctivitis, chroiditis etc and can eventually lead to deformity, birth defects and death. This poses a great threat to the residents living near it and the total environment in general. Some of these surface contaminants have the potential to run off or erode into adjacent surface water. This dump poses a high risk to public health and the environment.

Moreover, nearby residents complain of foul odour which often comes from the dump site, and frequent fog, which is as a result of burning on the site and sudden darkness has occurred around the area in some few occasions.

The landfill poses a great risk to agricultural productivity in terms of quality and quantity of farm produce. Elements such as zinc, lead, copper, cobalt, chromium etc. reduce soil nutrients; have negative influence on activity of micro-organisms which causes reduced productivity; and pose a great risk to man's health if this farm produce is consumed. These pollutants can lead to different kinds of diseases like cancer, anemia, damage to immune system, asthma, pneumonitis etc

In conclusion, this site has been regarded as a mere dump site, as regulation states that landfill that pollute surface waters or contaminate underground water should be considered "open dump". This site not only poses a high risk to the health of the residents around it, it also a threat to the life of the animals that feeds around it, and school children in schools 1 km away from the site and the environment generally.

Summary

From the analyses carried out, it was shown that fifteen communities, namely Aba-Eku, Akilapa, Jagun, Amuloko, Elesin, Odi-Odelyole, Badeku, Ogbere-Tioya, Asolo, Aba-emu, Moga, Akinfenwa, Ajia, Aba-Epo and Odi-Aperin with total population of about hundred thousand (100,000) people will be endangered by the negative impact of this site, two major rivers which falls within 1km buffer created around the site also stand the threat of being polluted by running water from the site.

Conclusion

From the study carried out, it was observed that the landfill site of the study area did not meet up with the standards set for such operations as the site is in close proximity to small towns and different land-uses such as educational and agricultural uses. The site poses a threat to these settlements, both surface and underground water and the environment as hazardous heavy metals were found in the samples.

Laboratory analysis of a water sample collected a kilometer away from the site also shows that surrounding waters have been polluted by heavy metals.

In essence, Aba-Eku Landfill site is considered as an “Open Dump Site” and appears to pose a high risk to the public health and the environment in general and there is a need for the body in charge of the site to respond by investigating and potentially remediating the dump.

Recommendation

Due to financial constraint, there are some other analyses that are not performed in the course of this study and it is therefore suggested that there is a need for the body in charge of the dumpsite to perform these analyses which include:

- Installation of soil boring for better define site hydrogeology waste contents and to check for methane gas.
- Proper soil gas survey is needed to determine whether contaminants have migrated deeper into the ground.
- Comprehensive analysis and monitoring of drinking water wells near the landfill site.

Field survey shows that the type of waste management practice at this site is mere open dumping and the surface issues at this dump could be remedied by applying additional cover to the dump, removal of waste materials or debris and vegetating the site to prevent erosion.

The site should be equipped with suitable channeling devices such as ditches, beams or dikes, to divert surface water runoff from areas contiguous to the dump. Well compacted, fine grained soils should be used for the final cover to prevent surface water runoff by minimizing infillation. This should be done at the end of each working day.

Some land use in close proximity to the dump may have to be changed, thereby changing the potential risk associated with the dump. There is a great need to enlighten the general public about the health implications of building around dump sites. There is a need to incorporate location of dumps into planning and zoning processes for proper practice of development control in order to restrict further encroachment on the dump, whether it is residential, commercial, industrial or recreational. There is also the need to summon the town planning department of Ona-Ara local government concerning the further approval of the buildings 3 km around the site.

From the survey and through the study carried out, we have to understand that government has been the major sector involved in waste management, given the magnitude of the resources required and competing demands required amongst the various economic sectors. Government can no longer be solely responsible for waste management. This situation prompted the need to look beyond public finances and to promote private sector and local community in waste management and there is a great need to enlighten the general public about the health implication of building around dump sites.

Considering the situation and state of waste management, there is a need for all urban development actors the public sector, the private sector, community groups and households to be involved in the planning and funding of waste management in Ibadan Metropolis.

References

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Streszczenie

Miasto Ibadan posiada cztery główne wysypiska śmieci, które stały się niemal małymi osiedlami. O ich wpływie na zdrowie czy środowisko wiadomo bardzo mało. Niniejsze badanie daje pewien obraz wpływu wysypisk śmieci na zdrowie, środowisko i gospodarkę oraz pokazuje zakres zagrożenia zarówno w odniesieniu do obszaru, jak i ludności.

W badaniu wykorzystano następujące metody – pozyskano informację o lokalizacji badanego obszaru, zgromadzono dokumentację, pobrano i przetestowano próbki gleby i wody, celem wykrycia w nich niebezpiecznych pierwiastków. Określono kryteria wykorzystania różnych map źródłowych i na ich podstawie opracowano bazy danych.

Aby ustalić położenie osiedli (z ich populacją), zbiorników wodnych i innych klas użytkowania terenu znajdujących się w pobliżu obszaru wysypiska śmieci oraz by sprawdzić, czy obszar ten spełnia standardowe kryteria dla wyboru miejsca wysypiska śmieci wykonano analizy funkcji sąsiedztwa, nakładanie warstw oraz zapytania przestrzenne (selekcja na podstawie położenia).

Wyniki analizy pokazały, że wszystkie spośród piętnastu osiedli w obrębie Obszaru Lokalnego Samorządu Ona-Ara, których łączna liczba ludności wynosi około 100,000, będą zagrożone negatywnym wpływem wysypiska. Sześć szkół oraz kilka gospodarstw rolnych znajduje się w buforze 1 km obszaru zagrożenia. W buforze tym znajdują się również dwie rzeki, które – jak pokazały analizy laboratoryjne – są zanieczyszczone wodami spływającymi z wysypiska.

Reasumując, wysypisko Aba-Eku uznane zostało za otwarte wysypisko śmieci, ponieważ nie spełniło ustalonych kryteriów i stanowi duże zagrożenie dla zdrowia ludzi oraz okolicznego środowiska. Zaleca się organom zarządzającym wysypiskami przeprowadzenie dalszych pomiarów, służących monitorowaniu i ograniczeniu ryzyka również w innych miejscach.

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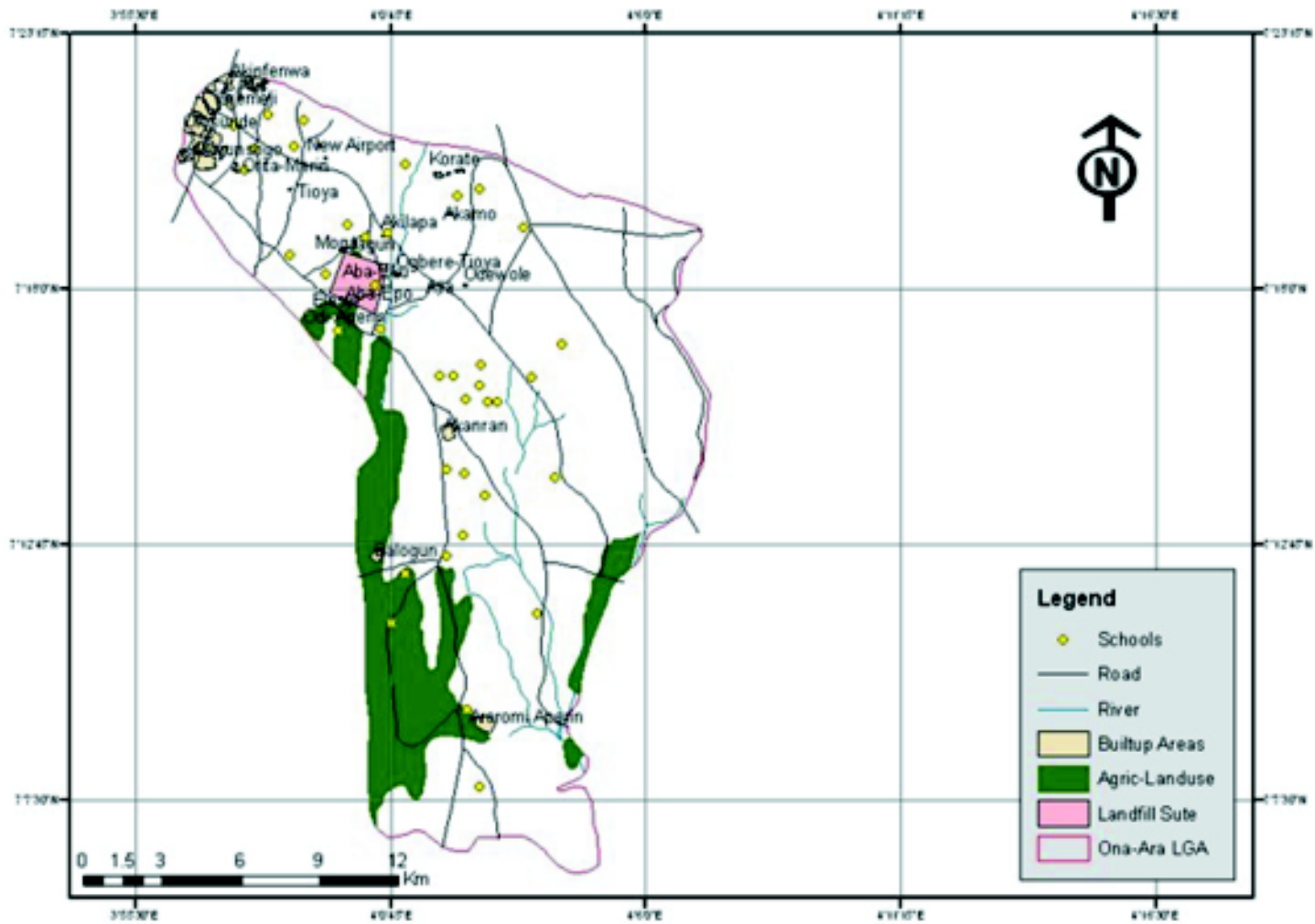


Figure 1. Map showing Aba-Eku and different landuses

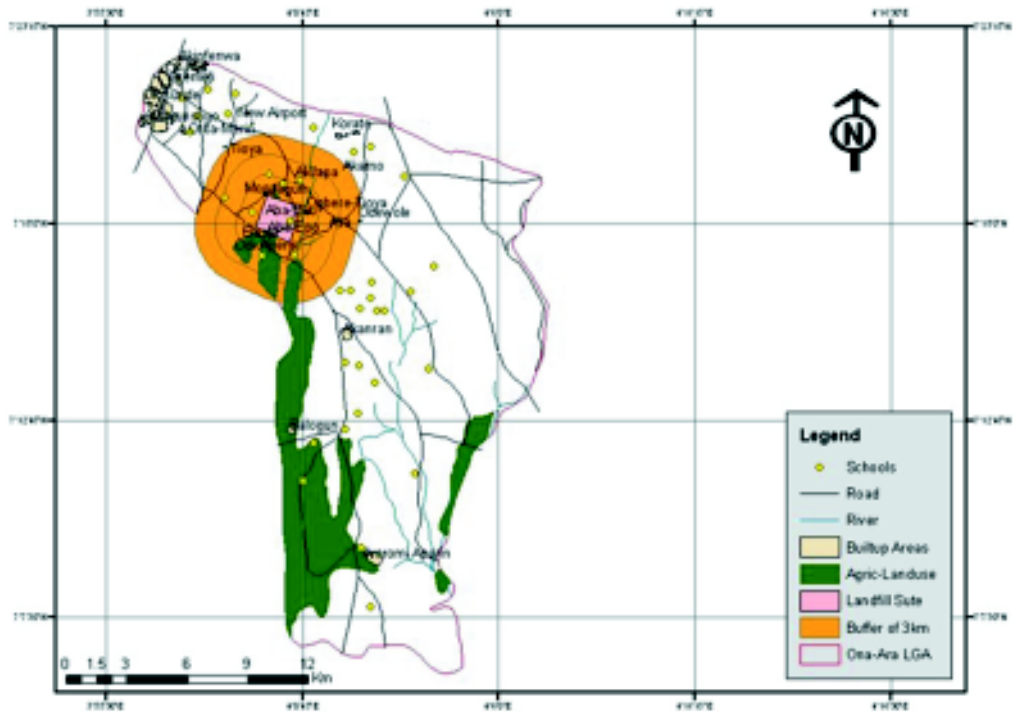


Figure 2. Map showing 3 km buffering and affected landuses

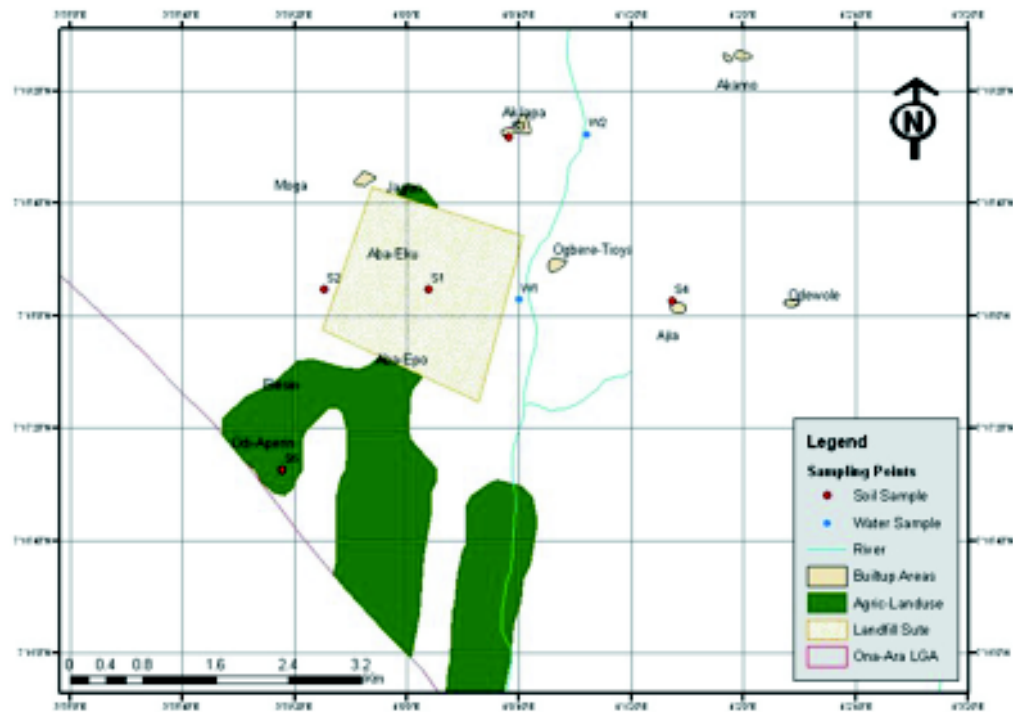


Figure 3. Proposed sampling map