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Groundwater Quality and Municipal Waste Management in Brikama, The Gambia

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Abstract

This paper describes groundwater quality and municipal waste management practices in Brikama Town, The Gambia. Waste management is generally through indiscriminate collection, open dumping, open burning without proper waste segregation or sorting. The domestic water supplies are entirely derived from groundwater resources. Some municipal water boreholes that supply raw water to the water treatment plant of Brikama for treatment are located within the main municipal waste dumpsite or thereabout. The main municipal water treatment technique is chlorination which cannot get rid of chemicals including nitrates and heavy metals, especially where waste disposal is through indiscriminate dumping. In Brikama, the waste management system has many lapses. Some of the lapses are related to some missing components of the waste management cycle. Such missing components include waste segregation and waste treatment which are as important as the other components such as collection, transportation and disposal. Other lapses are related to inadequate political and structural arrangements for the available components of the waste management cycle. There is felt need for more regulations to protect the environment. Workable legislation, regulations and action plans for groundwater resources and waste management should be put in place by the government and corporate municipal institutions without delay for public and environmental health protection.

La Qualité des eaux souterraines et la gestion des déchets municipaux à Brikama, Gambie

Résumé

Cet article décrit la qualité des eaux souterraines et les pratiques de gestion des déchets municipaux dans la ville de Brikama, en Gambie. La gestion des déchets se fait généralement par le biais d'une collecte sans discernement, d'une décharge à ciel ouvert, d'un brûlage à l'air libre sans séparation approprié des déchets. L'approvisionnement en eau domestique provient entièrement des ressources en eau souterraine. Certains forages d'eau municipaux qui fournissent de l'eau brute à la station d'épuration de Brikama pour traitement sont situés à l'intérieur de la décharge municipale principale ou aux alentours. La principale technique de traitement de l'eau municipale est la chloration, qui ne permet pas d'éliminer les produits

chimiques, notamment les nitrates et les métaux lourds, en particulier lorsque l'élimination des déchets se fait par le biais d'un déversement aveugle. A Brikama, le système de gestion des déchets présente de nombreuses défaillances. Certaines violations sont liées à certains éléments qui manquent du cycle de gestion des déchets. Ces composants manquants comprennent la séparation des déchets et le traitement des déchets qui sont aussi importants que les autres composants tels que la collecte, le transport et l'élimination. D'autres manquements sont liés à des dispositions politiques et structurelles inadéquates pour les composantes disponibles du cycle de gestion des déchets. Il y a un besoin ressenti de plus de réglementations pour protéger l'environnement. Une législation, des régles et des plans d'action applicables aux ressources en eaux souterraines et à la gestion des déchets devraient être mis en place sans délai par le gouvernement et les institutions municipales pour la protection de la santé publique et environnementale.

Introduction

Contamination of domestic groundwater sources by improper municipal waste management (MWM) has been reported by many studies around the world (Brindha & Elango, 2012; Gaye, 2015; Javahershenas *et al*., 2020; Kamble *et al.*, 2020; Tenodi *et al.*, 2020). In many industrialized countries, policy and technology combined help protect groundwater sources from possible contamination through municipal waste management issues. For example, in the European Union, waste management is characterized by practical and effective reduction, reuse, and recycle policies through the development of realistic regulations and by the policymakers' desire to simplify management systems (Sakai *et al.*, 2011). The ideal policy in China is the development of a circular economy that targets reductions in the amount and hazardousness of waste (Sakai *et al.*, 2011). Similarly, effluent discharges are well controlled. However, in the less industrialized countries, such policies are either non-existence or not effective in practice (Sakai *et al.*, 2011).

There is also laxity in the availability of best technologies for MWM. While landfilling is the least option for MW treatment in industrialized countries, the same is the most viable option in the less industrialized countries.

The Gambia is a typical developing country, where illiteracy and poverty rates are very high (GBoS, 2013). A large percentage of the citizenry do not consider improper waste management and its related consequences including groundwater contamination as a major public health issue (Sakai *et al.*, 2011). Yet, the main source of water supply for domestic and other purposes in Brikama is groundwater (Gambia Government, 2014). In Brikama, it is common to see people engage in throwing litter from moving vehicles, throwing domestic waste to illegal dumpsites, misuse of public property, littering public streets, dumping waste into gutters, littering of parks and recreational facilities. Some people live in places that are declared uninhabitable, such as inside the wetlands, waterways, dumpsites, etc.

Consequently, the illegal dumpsites created block natural waterways leading to floods and formation of water bodies that can harbor disease agents. Some of these agents either leach in the ground or stay on the surface. The health sector has suffered huge setbacks due to disease occurrences caused by pollution (GBoS & ICF, 2021).

Although there is a municipal water supply system in Brikama, a large population depends on well water for their domestic water supplies. On the other hand, waste disposal is through open dumping, indiscriminate dumping, and the use of pit latrines and soak-aways for excreta disposal. In some instances, people resort to turning abandoned wells for excreta and other wastes disposal. The WHO standard distances between groundwater sources and waste points could be compromised due to many factors including, small compound sizes, weak legislations and

regulations, ineffective implementation of policies and low level of awareness of groundwater contamination by waste management issues.

Quantities of household waste produced per capita in the Banjul City Council and Kanifing Municipality were estimated at 85 tonnes per day and only 30 tonnes per day was collected and disposed of in open dumpsites or crude landfills (Njie, 2017). The estimates for Brikama can only rely on what was observed in Banjul and Kanifing.

The Department of Water Resources on quarterly basis, monitors strategic water points for public health hazards. Selected parameters, which are specifically health-related, are done to ensure clean drinking water is obtained.

However, characterizing groundwater quality index as a function of waste management is not evident in Brikama, The Gambia. This review links waste management to the quality of drinking water, using established literature and standards. Although the WHO standards for drinking water quality is of help, National standards could be better. Currently, The Gambia is working on a wide range of water quality standards including mineral water quality standards, even if these standards are yet to be used by regulatory authorities. The aim of this paper therefore, is to discuss possible groundwater contamination through poor waste management issues that can affect the quality of groundwater that is used for day-to-day activities in Brikama, The Gambia.

The collection, transportation of disposal of, and treatment of waste are all important aspects of proper waste management. Adequate management of municipal waste is important for public health, the environment, as well as for economy and political reasons. Therefore, it deserves increased attention from municipalities and policy makers. Improper waste management can have negative effects on the environment and natural resources.

Consequently, it would impact on the economy and standard of people. Improper waste management is associated with many factors ranging from laxity in policies to poor implementation of policies relating to waste and environmental management.

Effects of Waste Management Pattern on Groundwater Quality

Globally, some studies have compared groundwater nitrate (NO^{3-}) concentrations from human-induced sources to background values (Menció *et al.*, 2011). Comparative analysis of GW NO^{3-} concentrations to both the WHO and national guidelines have also been documented (Yidana *et al.*, 2010; Rajendran and Mansiya, 2015). Other investigations focused on the occurrence and mobility trends of contaminants including sources identification (Zhang *et al.*,

The figure below depicts a possible interaction between the surface and the ground aquifer

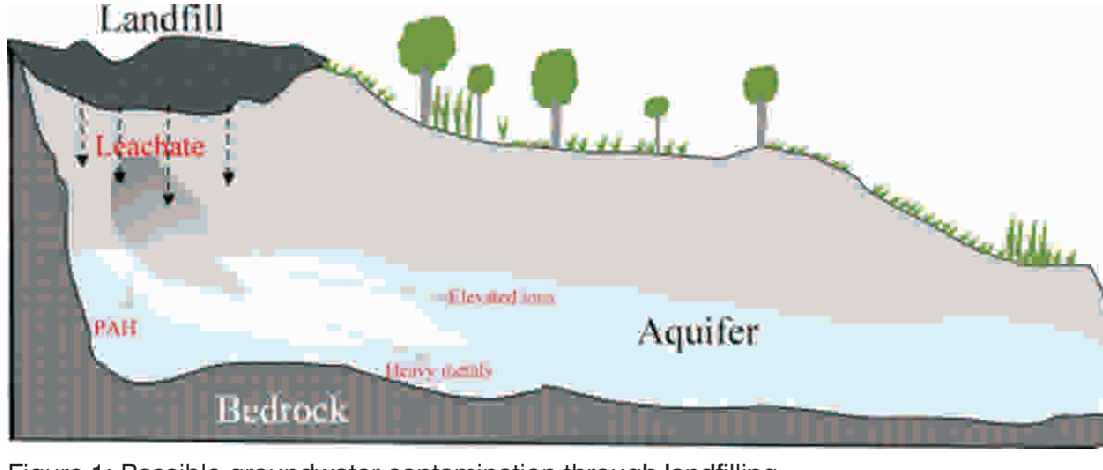

Figure 1: Possible groundwater contamination through landfilling
Source: http//:www.googlescholar

2015;). An inventory of GW NO^{3-} levels in Ghana, conducted in the northern part indicated rising levels (0–65 mg/L) between 1977 and 1980 compared to 0.4–10.6 mg/L between 1959 and 1977 (Egbi, *et al.,* 2020). Subsequently, Yidana e*t al.* (2012) reported values of 194.65 mg/L and 120 mg/L and suggested manure and sewage as possible sources. Likewise, Helstrup *et al.* (2007) noted 62 mg/L (NO^{3-}) in southern Ghana and indicated poorly managed sewage systems as probable transmission sources.

In The Gambia, the Department of Water Resources on quarterly basis, monitors strategic water points for public health hazards. Selected parameters, which are specifically-health related, are done to ensure clean drinking water is obtained, such as:

i. Bacteriological such as Thermotolerant Fecal Coliform (F.C.) test
ii. Physico-chemical such as pH, Electrical Conductivity and Total Dissolved Solids
iii. Part-chemicals (Nitrate and Total iron).

During the 2012 rainy season, fecal coliform counts peaked especially during August and September. There was variation in the total and fecal coliform counts at different locations. Water quality data from settlements near urban sites had higher total and fecal coliform counts compared with settlements that were away from urban centres (Gambia Government, 2014).

Rapid urban growth induces global environmental change, particularly when it comes to the generation of waste. According to the United Nations (2020), most of the world's population will be living in cities by the year 2030 (Tsalis, *et al.,* 2020). In developing countries, urban agglomerations are growing at twice the rate of overall population growth. Each year, approximately 160,000 people migrate from rural to urban areas. The estimated urban growth rate for developed regions is 0.5% compared with 2.7% in less developed regions, and 4.5% in least developed regions (Tsalis, *et al.*, 2020).

The urban areas of The Gambia account for 16% of the land area, on which more than 50% of the population lives (GBoS, 2013). This highly populated area – basically constituting the Greater Banjul Area is therefore prone to poor sanitary conditions, high waste generation and pollution in general as well as higher demand for water. In the urban areas, there is also an industrial sector. The sector is still quite modest in The Gambia and is mostly limited to plastic materials production, agro-based soap production, candle production, a brewery, bottlers, confectionery production, sand and gravel mining among other small-scale industries. These industries can be a cause for concern in terms of water quality, as chemicals and other discharges can pollute surface water and groundwater if not handled appropriately. As development continues, the industrial sector is also likely to grow and this is an important factor to consider for future water quality monitoring.

Groundwater Resource Management

The Department of Water Resources is responsible for the development, utilization and protection of groundwater in The Gambia. They issue permits, which are required for both borehole drilling and groundwater abstraction. The National Water and Electricity Company (NAWEC) is mandated to provide water supply in the Greater Banjul Area including Brikama and the surrounding settlements. In Brikama, NAWEC is the sole municipal water provider for its 125 000 inhabitants. The 1,500 metre squared water treatment plant was established at a cost of twenty-five million (25, 000,000) Euro in the year 2006, and it started operations in July, 2009. It has seventeen bore holes, one located within the perimeters of the plant, one located within the Tambana municipal dumpsite and the other fifteen are located in different locations in Brikama. The boreholes depth ranges from 50 metres, to 80 metres. Due to the late establishment of a municipal water supply system, many homes and dwellings in Brikama resorted to digging wells as source of water for drinking and domestic purposes. Brikama is currently the fastest growing town in The Gambia, (GBoS, 2013) without any municipal sewage and sewerage system. The population boom is making more people dwell on smaller land spaces. Also, more recent residential buildings are getting smaller. Thus, appropriate spacing between water wells and possible contaminants such as pit latrines, dumpsites, and cesspools is becoming a cause for concern.

Groundwater Monitoring

The national water supply in Gambia is derived entirely from groundwater. The following groundwater abstractions are currently known: 207 boreholes with hand pumps, 260 boreholes with solar pumping systems, 84 boreholes with electric pumping systems, and 1634 hand dug wells with hand pumps (Department of Water Resources, 2020). Groundwater abstraction from the main unconsolidated aquifer (Shallow Sandstone Aquifer) is less than average annual recharge. Total groundwater availability could be significantly increased by exploiting the Deep Sand Aquifer.

The Department of Water Resources established a network of 38 groundwater level and quality monitoring boreholes in 2014 (Gambia Government, 2014). These are distributed across Gambia and are equipped with automatic data loggers. The recorded groundwater level observations are collected every three months, and the data is stored in the GeOdin database with the Department of Water Resources. The same network is used to monitor groundwater quality. However, the only monitored parameters are: salinity, temperature, groundwater level, electric conductivity and pH.

Classification of Waste

Waste can generally be classified as solid, liquid, or gaseous based on the physical form. The solid form can be household, plastic, office, metallic waste, etc. The liquid waste comprises effluents from textile, tanneries, distilleries, pharmaceutical industries, etc. The gaseous waste includes the wastes from chemical industries, power plants, and metallurgies.

Based on the impact on human health, wastes are classified as nontoxic, toxic, or pathogenic. Kitchen waste, paper, cotton, fruits, and vegetable peels are considered as nontoxic waste as they do not have much impact on the human health and they are easily biodegradable. The industrial waste from chemical, pharmaceutical, metallurgies, nuclear, or electronic comes under the category of toxic or hazardous waste (Sakai *et al.*, 2011).

Appropriate strategies have to be developed for the disposal of these wastes as they have impact on human health. A major concern is with the hospital waste which is pathogenic to humans as well as animals.

E-waste is an emerging waste stream globally due to the high consumption of electronic products. It includes all technological, electrical and electronic devices that are coming from the informatics industries, from the manufacturers of electronic products that, at the end of their useful life due to their characteristics, require special handling (Saldaña-Durán *et al.,* 2020). Integral E-waste management presents great challenges for developing countries such as The Gambia without the proper recovery technology. The complexity of diverse components of electronic equipment and products make them difficult to recycle.

However, a number of shops use human labour work on disassembling the main components and materials to sell them in local markets. The lack of E-waste collection infrastructure, as well as the absence of consumer awareness are the main obstacles for an environmentally sound E-waste management programme in developing countries.

Waste Management

The actor network of waste management study by Méndez-Fajardo *et. al.*, (2014) indicated that waste management is an impossible task for councils alone. They suggested that the actor network theory should be used to single out actors which are involved in waste management, intimate them of their importance and the role they play in the network. Area network theory can also facilitate locating the root of waste management problems.

Private enterprises may play a role in vastly improving waste management in Africa but compared to developed country models, the African models require greater involvement of providing waste management services from pre-collection to recycling and composting. Most settlements are planned in the developed countries such that vicinities of waste production are more homogenous than the realities in developing countries. For example, in a purely industrialized city like Birmingham, in the United Kingdom, waste produced could be more homogenous than

that of a city with unplanned activities which is often the case, in developing countries like Brikama in The Gambia.

Three 'R' Approach for Waste Management

One of the important principles of waste management is waste hierarchy which has a basic motto of maximizing the practical benefits of products and minimizing the end waste (Sakai *et al.*, 2011). Three concepts in waste hierarchy are three 'Rs' which represents Reduce, Recycle, and Reuse. Each option of the hierarchy has been built up as a diversion from landfill-based disposal issues which was one of the major concerns earlier (Van and Stegemann, 2014).

The first step of the waste management hierarchy is 'reduce.' This is based on the principle of less consumption which ultimately results in less waste to be recycled or reused (Sakai *et al.*, 2011). Alternatively, when the waste generation is less, it has less stress on the other two 'R's. One of the issues is elevated usage of disposable products. They are very handy and can be discarded after use and therefore, more preferable by the people. However, these disposable products pose challenge for the environment in terms of recycling. The use of durable products is encouraged as it would avoid multiple purchases which in turn would reduce waste being generated. Liquid waste is reduced through well managed ecosystems while gaseous waste reduction is through emission control programmmes. Currently, the Glasgow Convention, COD26 has recommended renewable energy in place of fossil fuel for energy supply. At the time of writing this report, The Gambia does not have any control programmes for liquid and gaseous waste control.

The second 'R' of the waste management hierarchy is recycling which is the process of converting waste materials into new usable materials and objects. Recycling can save material and help to reduce greenhouse gas emissions.

Thus, recycling aims at environmental sustainability by substituting raw material inputs into and redirecting waste outputs. There are some standards related to recycling such as ISO 15270:2008 for plastics waste and ISO 14001:2004 for environmental management control of recycling practice. One of the challenges faced in the implementation of recycling is the segregation of waste products that can be recycled from the products which cannot be recycled. Effective plans should be made for the proper collection, segregation, and recycling of waste materials. Liquid waste recycling is a lucrative trade in some countries. Sewage is recycled and the byproducts used for agricultural, and commercial purposes.

The third 'R' of waste management hierarchy is 'reuse'. Reuse is the action of using something again, whether for the original purpose or for a different function (Sakai *et al.*, 2011). Reuse is different from recycle. reuse conserves energy, time, and money. In The Gambia, sewage from hotels disposed off in lagoons is reused by farmers nearby to water plants in a subsistence scale. The reuse of gaseous waste is not evident in The Gambia.

Conclusion

Groundwater is the most accessible and reliable source of potable water across Sub-Saharan Africa (El-Naggar & El-Naggar, 2015). It is well established that anthropogenic activities such as waste management from point of generation through discharge can affect the quality of the water just beneath the earth surface in numerous ways (Lerner, D. N., & Harris, B., 2009).

In developing countries, the waste management system has many lapses. Some of the lapses are related to some missing components of the waste management cycle. Such missing components include waste segregation and waste treatment which are as important as the other components such as collection, transportation, and disposal. Other lapses are related to inadequate political and structural arrangements for the available components of the waste management cycle. There is felt need for more regulations to protect the environment. In The Gambia, where municipal waste management is the mandate of councils and municipalities (BAC, 2015), proper waste management need not be a mirage despite several socio-economic factors, including age level and distribution,

family income and size, education, commodity price, price of recycled materials, home tenure (private versus rental) areas, race, climatic condition, waste collecting frequency as well as composting, being crucial to its implementation. (Adelekan & Alawode, 2011; Eveth *et al.*, 2016; Javahershenas *et al.*, 2020; Najafi Saleh *et al.*, 2019). Collected waste is disposed of in different forms such as: open dumping, land filling, or incineration. All of these forms cause direct threats to human health through water, air, and/or soil contamination. Other management alternatives are recycling, composting, and waste minimization.

Landfills create a number of environmental problems and costs. Besides using up space, they release carbon dioxide and methane gas, which contribute to groundwater contamination. Garbage dumps, particularly if uncontrolled, are also associated with environmental hazards due to toxic leachate and contamination of drinking water sources. Incineration causes severe effects, such as the generation of toxic ashes and air pollution, and is also waste of resources.

Incineration of plastics (Polyvinyl Chloride, PVC and Polyethylene Terephthalate, PET) releases dioxins, furans, and heavy metals, among others, which are linked to the development of ailments such as, cancer and damage to the human immune system (Pharoah, 2016). Furthermore, developing countries usually have to opt for less expensive incineration facilities, which usually mean less environmentally friendly technology. Neither incineration nor land filling create employment, but rather eliminate jobs from the recycling sector by burning or dumping the resources that could be recovered or reused for other purposes. Policies that promote more environmentally-friendly approaches to waste and groundwater quality management need to be promulgated for socio-economic growth and development.

Recommendations

Developed countries have established regulated programmes for the disposal of wastes, whilst developing countries have generally continued to use unsophisticated methods such as open dumps. In general, there is lack of organization and planning in waste management due to inadequate information about regulations and due to financial restriction in many developing countries. In most developed countries, workable legislation, regulations and action plans are in place.

However, waste disposal in developing countries is still largely random and uncontrolled, and large quantities of waste go uncollected on daily basis (Egbi *et al.,* 2019).

The municipal corporations such as the Area Council should collect the waste materials and segregate them appropriately instead of dumping them without assessing their recyclability.

Proper sanitary landfills should be established supported by well-organized waste collection and disposal services to curb the increasing waste problems in Brikama.

The Department of Physical Planning should work with local authorities in Brikama to plan for the city such that the environment is protected.

Services of private companies which can recycle the waste and convert them into usable products should be utilized. People should be encouraged to use recyclable products and the benefit of the same should be explained to them. This will create jobs and minimize wastes produced.

The Brikama Area Council and the National Water Electricity Company should collaborate to stop the boreholes that are located in the Tambana Municipal Dumpsite and other boreholes that are reasonably close to the dumpsite.

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