



# **Waste Characterization Study to Mitigate a Land Based Source of River Pollution: Case of Nkam River in the Yabassi Municipality**

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/JGEESI/2018/44894

#### Editor(s):

(1) Dr. Wen-Cheng Liu, Department of Civil and Disaster Prevention Engineering, National United University, Taiwan and Taiwan Typhoon and Flood Research Institute, National United University, Taipei, Taiwan.

#### Reviewers:

(1) Mithra Dey, Assam University, India.

(2) Aiqin Wang, Xi'an Jiaotong University, China.

Complete Peer review History: <http://www.sciencedomain.org/review-history/27525>

**Original Research Article**

**Received 01 September 2018**

**Accepted 08 November 2018**

**Published 01 December 2018**

## **ABSTRACT**

**Aims:** The research work is aimed at evaluating the land base source of River pollution using a waste characterisation study in the Yabassi municipality in order to design strategies for mitigating pollution of the Nkam River.

**Study Design:** A household survey involving random sampling of 45 households in three residential neighbourhoods (Banya, Ndogbele and the Administrative Centre) to determine their socioeconomic status. Of a total of 117 participants, 45 (44.0%) lived in Banya, 30 (34.2%) in Ndogbele and 25 (24.8%) in the Administrative Centre.

**Place and Duration of Study:** Yabassi Municipality involving three residential neighbourhoods (Banya, Ndogbele and the Administrative Centre) between February and July 2017.

**Methodology:** Household surveys involving three residential neighbourhoods (Banya, Ndogbele and the Administrative Centre) in the Yabassi municipality was carried out to identify individuals belonging to the three socio-economic income classes (low, medium and high). A questionnaire was administered to 117 persons randomly selected from 45 households i.e. 15 from each of the three residential neighbourhoods to participate in a two weeks waste characterisation study. The

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waste produced by the participating households was sorted manually at the source, weighed using a mechanical balance and classified into 6 categories: organic materials, plastic bags and bottles, glass, textile, metal, cardboard and paper. Participant observation and participatory appraisal methods were used throughout the field study to make acquaintances with the household structure and informal structure, evaluate the performance of waste collection, disposal and treatment methods in the low, medium and high residential areas, identify constraints faced by households in the collection and disposal of wastes. Make a direct observation and visual evaluation of clandestine garbage dumps near the Nkam River to identify land based pollutants.

**Results:** The 117 persons randomly selected from 45 households in the Yabassi municipality produced 709, 5 kg of solid waste in two weeks that gave a per capita waste generation rate (kg/persons/day) of 0.43 kg per day. The average percentage composition of the household waste in the three residential neighbourhoods showed organic waste material as the most dominant waste fraction (Banya 70%, Ndogbele 63.8% and the Administrative Center 19.9%). The large quantity of organic waste material in Banya and Ndogbele can be explained by its large populations, their socioeconomic status classified as low and medium respectively with a majority of the inhabitants involved in agriculture and fishing. In general lifestyle and culture is greatly influenced by socio-economic activities (agriculture and fishing) of the inhabitants of Banya and Ndogbele with major influence on their feeding habits with cassava, plantains, fish and green vegetables being the stable foodstuffs. The small quantity of organic waste material (19,9%) in the Administrative Center was due to the low population, the high socioeconomic status (civil servants and economic operators). The large quantity of recyclables e.g. metal (44%), plastic bag, glass (17%) and bottles (12,2%) could be linked to the increase in consumption orientated lifestyles and qualitative change in consumer goods in Cameroon. Metal, paper and carton have a high correlation between them and because it is an important to source of income in a developing country like Cameroon, municipal authorities and policy makers must carry out reforms in the waste management sector by creating recycling industries.

**Conclusion:** Given the increasing population of Yabassi, there is the qualitative and quantitative increase of household waste with the likelihood of it being clandestinely dumped in Nkam River. The results of this study will provide the municipal authorities with the strategies and tools for mitigating such land based pollutants moving into the Nkam River which has always provided basic amenities in terms of drinking water and a source of livelihood for the predominantly agrarian and fishing populations. Some mitigation measures to be adopted should include identification of pollution sources and the obligatory use of plastic bags and refuse bins for the collection and disposal of household waste and containers for the storage of household waste until they are collected by the local authorities. In addition intensive community education on ocean literacy and awareness raising regarding waste management best practices is carried out.

*Keywords: Pollution; waste characterisation study; Yabassi municipality; Nkam River.*

## 1. INTRODUCTION

Land-based pollution represents the single most important cause of fresh water and marine pollution [1]. because they are sites of high biological productivity [2]. Land-based sources vary from municipal or household waste, industrial or agricultural sources. Several studies indicate that much of the municipal solid waste (MSW) from developing countries are generated from households (55–80%), followed by commercial or market areas (10–30%) with varying quantities from streets, industries, institutions among others [3,4,5].

It has been estimated that at least 60 percent of the world's population live within 100 km

of the coast; hence it is conceivable that with rapid population growth particularly in the developing world, river pollution from land-based activities will become more problematic [6]. According to Philippe and Culot [7], MSW has increased in size in several cities in the developing countries causing negative effects in terms of waste collection, disposal and elimination. This is because the urban centers are ill equipped with urban infrastructures and are unable to handle the increasing quantities of MSW [8].

In the past, men thought that the environment has an immeasurable capacity to demolish his waste without any impact on human health. More recently, however, man's health and welfare are

being affected by environmental pollution. These pollutants are substances present naturally in the environment but when released in a significant amount from anthropogenic activities, become toxic [9]. This increasing concern for its toxicity has drawn man's attention to the water quality of rivers. The water quality from the rivers has a considerable importance for the reason that these water resources are generally used for domestic and residential water supplies, agriculture (irrigation), hydroelectric power plants, transportation and infrastructure, tourism and recreation [9]. This is the case with a semi urban area such as Yabassi with agrarian and fishing populations living very close to the Nkam River. In the absence of household or municipal waste collection services, residents have adopted some unscientific methods by disposing their waste into the Nkam River or burning, a major concern why this research work was carried out. The situation has even worsened by the lack of data on waste characterisation for use by municipal authorities to design strategies and formulate policies to prevent pollution of Nkam River from land based pollutants.

Many authors [10,11,12,13] have used a waste characterisation study to determine the physical composition and chemistry of MSW and establish a waste management programs for MSW disposal, recycling and planning. There are alternatives to properly manage waste, but it is necessary to know first the intrinsic qualitative and quantitative characteristics of waste in order to make the right decision as to which of them is right for the community [14,15,16] and secondly collection, handling and ways of disposal. Therefore, the first step towards the solution is MSW characterisation because it provides information on MSW generation, specific weight and composition [17]. It also allows strengthening up the decision-making and improving the planning and management of waste for its use and final disposal. There are however other aspects that can influence the success of the management system and the decision-making, but for their understanding, studies with a qualitative approach have to be conducted. For example: the change in the conduct of the generators with the purpose of minimizing waste generation and increasing recycling or the effect of education in order to understand the importance of improving the waste collection service and the disposal of MSW [18,19]. It is for this reason therefore that, the current study was carried out with the objective of characterising

household waste as a land based pollutant in the three residential neighborhoods (Banya, Ndogbele and the Administrative Centre) in Yabassi of the Nkam municipality.

## **2. MATERIALS AND METHODS**

### **2.1 Overview of the Study Area**

The Nkam River rises in the Western High Plateau in the West Region of Cameroon and joins the Makombe River to become the Wouri River. It is known to tourists for the remarkable Ekom waterfall, an 80 meters (260 ft.) high waterfall about 30 km from Bafang [20]. The Nkam River has great potentials with regards to fish farming with an annual flooding in the river valley providing millions of catfish juveniles. These are caught for immediate consumption, or to restock ponds used for aquaculture [21].

Yabassi is a semi-urban town located in the Littoral Region of Cameroon and chief town of the Nkam municipality. The town's economy is essentially based on rural agriculture employing more than 90% of the population. The main products of agriculture are cocoyam's, cassava, potato, yam, plantain, etc. In recent years, there has also been a proliferation of oil palm cultivation. This is made possible by the fertile soil of the area. The second economic sector is the small business sector while the fishing and hunting sectors are also quite active, but artisanal [22].

### **2.2 Household Surveys**

Household surveys involving three residential neighbourhoods (Banya, Ndogbele and the Administrative Centre) in Yabassi of the Nkam municipality was carried out to identify individuals belonging to the three socio-economic income classes (high, medium and low). The high income residential areas were made up of single detached houses, the medium income residential area made up of multiple occupancy properties and the low income residential areas made of illegal and non-permanent structures or houses in unplanned and squatter settlements and occupied by struggling families with very low income [23]. Questionnaires administered to 117 persons randomly selected from 45 households i.e. 15 from each of the three residential neighbourhoods to participate in a two weeks waste characterisation.

### 2.3 Weighing of Sorted Waste

Waste produced by the participating households (45) were sorted manually at the source, weighed using a mechanical balance and classified into 6 categories: Organic materials, plastic bags and bottles, glass, textile, metal, cardboard and paper for 2 weeks. The choice of 45 households is in line with Parfitt and Flowerdew [24], Parfitt [25] who recommended a sample size of 40 households and Parizeau et al. [12] who sampled 49 households in Siem Reap-Cambodia. Descriptive statistics were used to determine the average per capita waste generation and the percentage composition of the different waste fractions in line with Pichtel [26].

### 2.4 Participant Observation and Participatory Appraisal

Participant observation and participatory appraisals were carried out throughout the field study to make acquaintances with the household structure. Participatory appraisals were also used to evaluate the performance of household waste management involving waste collection, disposal and treatment methods in the low, medium and high-income residential areas. Participant observation was used to make direct observation and visual evaluation of clandestine garbage dumps near the Nkam River and to identify land based pollutants. It was also used to identify the constraints faced by households in the collection and disposal of wastes. Participatory appraisal is an approach of learning about communities that place equal value on the knowledge and experience of local people with different background and experience and their capacity to come up with solutions to problems affecting them [27].

## 3. RESULTS AND DISCUSSION

### 3.1 Municipal Solid Waste Generation per Capita

Municipal solid waste generation, a core indicator of environmental pressure is a useful measure for evaluating the intensity of waste generation over time and comparing the intensities among cities or countries [28].

Municipal solid waste generation per capita varies among municipalities within countries. Urbanization has a positive effect on increasing

MSW generation per capita, especially in developing countries, where differences in economic activities and living standards between rural and urban areas are large. MSW per capita in urban municipalities has been reported to be more than that in rural municipalities in developing countries. For example, in Vietnam, MSW generation per capita was reported to be 0.70 kg /person/day in urban areas and 0.30 kg /person/day in rural areas [29].

The 117 persons randomly selected from 45 households in Yabassi of the Nkam municipality produced 709,5 kg of solid waste in two weeks with a per capita waste generation rate of 0.43 kg /person/ day. This is in line with the other municipalities in sub-Saharan Africa countries which ranged from 0.2 to 0.8 kg/person/day [30,31]. Notwithstanding, although MSW per capita is simply calculated as the amount of MSW generated divided by the population with MSW collection service uncertainty in either value can negatively affect the reliability and comparability of the data [29].

### 3.2 Percentage Composition of Household Waste

The average percentage composition of the household waste in the two residential neighbourhoods is illustrated in Figs. 1 and 2. The organic waste material was the most dominant waste fraction (Banya 70%, Ndogbele 63.8%). The large quantity of organic waste material in Banya and Ndogbele is due to its large populations, their socioeconomic status classified as low and medium income residential areas respectively with the majority of the inhabitants involved in agriculture and fishing.

In general lifestyle and culture is greatly influenced by socio-economic activities with major impacts on feeding habits. In the two case study areas mentioned above cassava, plantains, fish and green vegetables are the stable foodstuffs with large quantities often discarded because many households either lack refrigerators or due to the unreliable electricity supply. In the absence of any waste collection service in these neighbourhoods the waste dumps often act as sources of land based pollutants with Nkam River as their next destination during heavy rainstorms. The effect of lifestyle and culture on household waste generation is well documented in some developing countries where coal is used for heating in winter (e.g. Ulan Bator, Mongolia)

and in Seoul where a significant proportion of the resident waste was charcoal ash up to the 1980s [32]. Waste in South Korea was also found to have high moisture content because Koreans eat a lot of Kimchi (Korean Pickle), a contributing factor for the weight increase of the putrescible fraction [32]. The small quantity of organic waste material (19.9%) in the Administrative Center (Fig. 3) was due to the low population, the high socioeconomic status (civil servants and economic operators). The large quantity of recyclables e.g. metal (44%), plastic bag and bottles (12.9%), glass (17%) could be linked to the increase in consumption orientated lifestyles and qualitative change in consumer goods in Cameroon. Research findings that revealed strong links between lifestyle and composition of waste generated has been

reported in Tanzania [33] and Makurdi in Central Nigeria [34].

Direct observation also provided evidence to the different solid waste found at 10 clandestine waste dumps at the vicinity of the Nkam River. We identified six categories of solid waste fraction from which a correlation analysis was conducted (Table 1): Organic material (banana, plantain, cocoyam and cassava peelings), Plastics (plastic bags and bottles), Metals (sardine cans), Glass (wine and used pharmaceutical bottles), Textile (second hand clothes) and Paper and carton. In the absence of a collection service and with the increase in population of the riverine communities, there was an unprecedented increase in solid waste with the Nkam River as the ultimate disposal route.

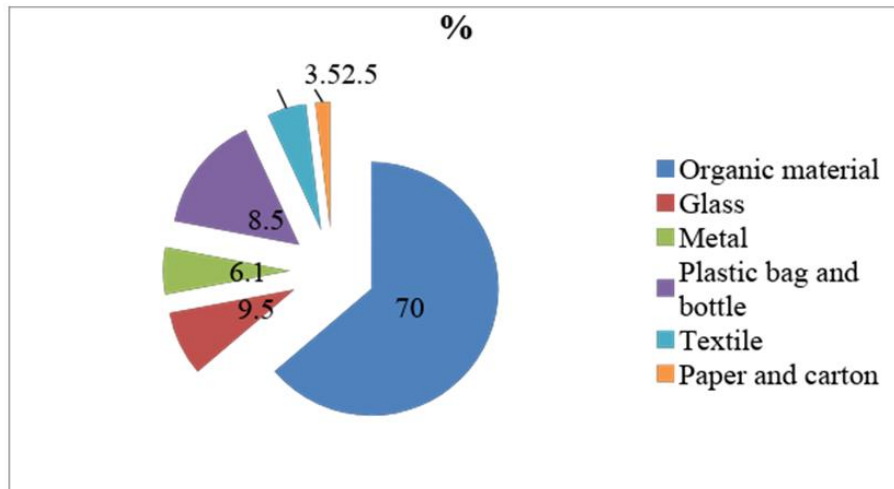


Fig. 1. Average percentage composition of the household waste – Banya

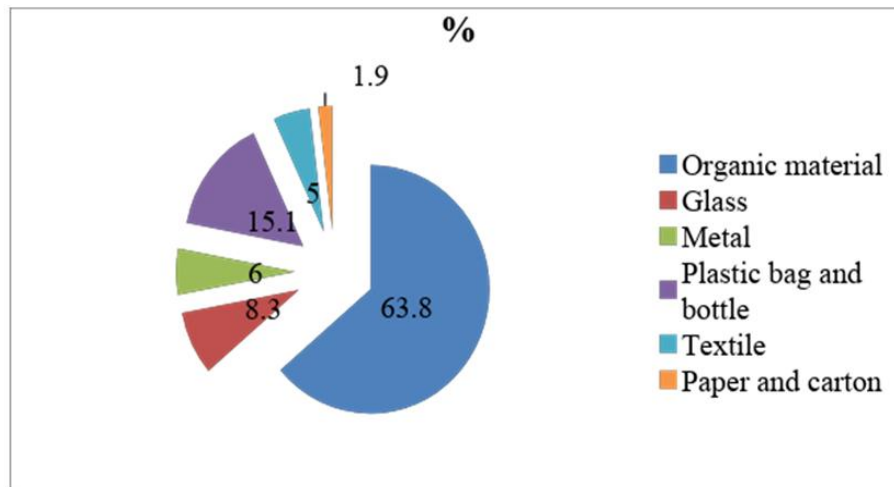


Fig. 2. Average percentage composition of the household waste - Ndogbele

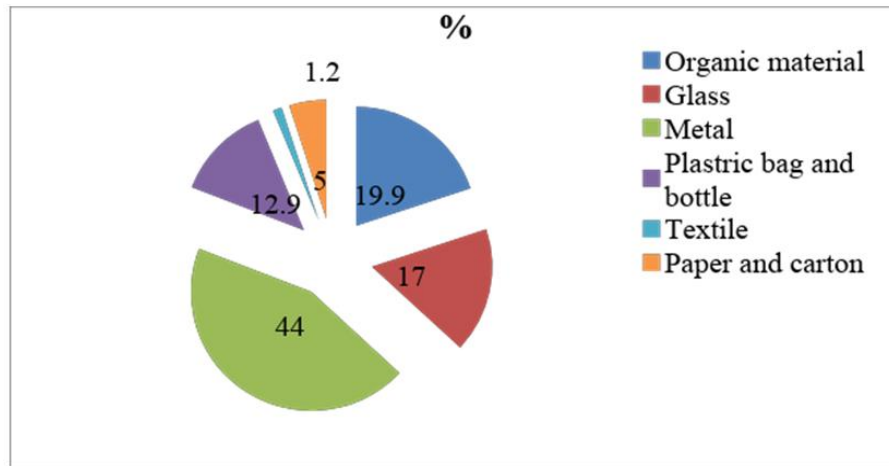


Fig. 3. Average percentage composition of the household waste -administrative centre

Table 1. Correlation analysis

Correlation	Organic materials	Plastic bags and bottles	Textile	Glass	Metal	Paper and carton
Organic materials	1					
Plastic bags and bottles	-0,2951	1				
Textile	-0,3066	-0,4097	1			
Glass	0,4202	0,2046	-0,5722	1		
Metal	-0,2759	-0,2039	-0,0773	-0,0608	1	
Paper and carton	-0,2145	0,0240	-0,1138	-0,5073	0,1259	1

Source: Calculation of authors (2018)

In Table 1, the correlation analysis shows that the organic material has a negative correlation with plastic bags and bottles, textile, metal and paper and carton. However, organic material has a weak positive correlation with glass. Also, metal, paper and carton have a high correlation between them. Since metal, paper and carton are important sources of income in a developing country like Cameroon, municipal authorities and policy makers must carry out reforms in the waste management sector by creating recycling industries. In addition, paper and carton can be combined with biodegradable organic waste materials e.g. food waste to produce compost for use in agriculture and aquaculture.

#### 4. CONCLUSION

The present waste characterisation study, participant observation and participatory appraisal methods provided insights as to the potential land based pollutants of the Nkam River, a source of basic amenities in terms of drinking water and of livelihood for the

predominantly agrarian and fishing populations. Some mitigation measures to be adopted should include identification of pollution sources and the obligatory use of plastic bags and refuse bins for the collection and disposal of household waste and containers for the storage of household waste until they are collected by the local authorities. In addition, intensive community education on ocean literacy and awareness raising regarding waste management best practices are carried out. The results of the waste characterisation, participant observation and participatory appraisal showed the organic waste fraction was dominant with the advantage of it being transformed into organic manure (compost) for use in agriculture and aquaculture and the non-organic solid waste fractions recycled or reused thus mitigating pollution of the Nkam River.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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