IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 12, Issue 3 Ver. III (March. 2018), PP 24-37
www.iosrjournals.org

Problematic of the Valorization of Solid Waste in The City of Porto-Novo In Benin

Brice Saturnin Dansou[1], Léocadie Odoulami[2]
[1]*Laboratoire Pierre PAGNEY, Climat, Eau, Ecosystème et Développement (LACEEDE/DGAT/FASHS/ Université d'Abomey-Calavi (UAC). BP :47 Abomey-Calavi, (République du Bénin) (Afrique de l'Ouest)*
[2]*Laboratoire Pierre PAGNEY, Climat, Eau, Ecosystème et Développement (LACEEDE/DGAT/FASHS/ Université d'Abomey-Calavi (UAC). BP :47 Abomey-Calavi, (République du Bénin) (Afrique de l'Ouest)*
Corresponding Author: Brice Saturnin Dansou

Abstract: *Waste management represents not only a fundamental ecological challenge for the city of Porto-Novo but also a socio-economic opportunity because it creates jobs.*
This study analyzes waste recovery strategies implemented in the city of Porto-Novo. The socio-economic data on the forms of recovery of waste as well as the benefits resulting from waste recovery were collected from 600 households surveyed. They were stripped and then processed using the tools of descriptive statistics. They are then supplemented by interviews with 42 resource persons as well as information on the experiences of waste recycling in the world.
The results show that in the city of Porto-Novo, two possibilities for recovery are offered to the waste when they are not directed towards a final discharge (controlled or not). This involves material recovery (reuse, recycling reuse) and energy recovery. These strategies are small-scale and do not allow populations to benefit significantly from their wastes. The appropriation of waste recycling experiments in Benin and in the world is essential for integrated waste management in the city of Porto-Novo.
Keywords: *Benin, Porto-Novo city, valorization, waste*

Date of Submission: 20-03-2018 Date of acceptance: 03-04-2018

I. Introduction

Since the early 1990s, the protection of the environment has become a collective concern. In Benin, despite the various texts governing the sector, the issue of the environment in general and waste management in particular is an unavoidable reality and a topical subject, since it constitutes a burden for the populations who live mostly in urban areas (Gbinlo, 2010).

Among the cities of Benin, only the city of Cotonou is trying to find a solution to the question of waste management (Yemadjè, 2015). Thus, if the mechanism put in place is not yet effective, from the point of view of pollution and the economic potential offered by waste, an effort is made. In the other cities, the evolution of lifestyles and the invasion of waste have posed a new environmental challenge over the last two decades, which is of concern to all actors in urban life (Dossou-Yovo, 2013). While waste has long been regarded as worthless residue, production and consumption activities as well as consumers now recognize that waste treatment is the ecological challenge of the end of this century, (Wilson et al., 2003). In the city of Porto-Novo, the difficult economic context faced by several households has encouraged the development of a new economic activity: the recovery of waste. What are the current valorization experiments in the city of Porto-Novo and how can they be improved? It is to these concerns that this research responds in the city of Porto-Novo in southern Benin (figure 1).

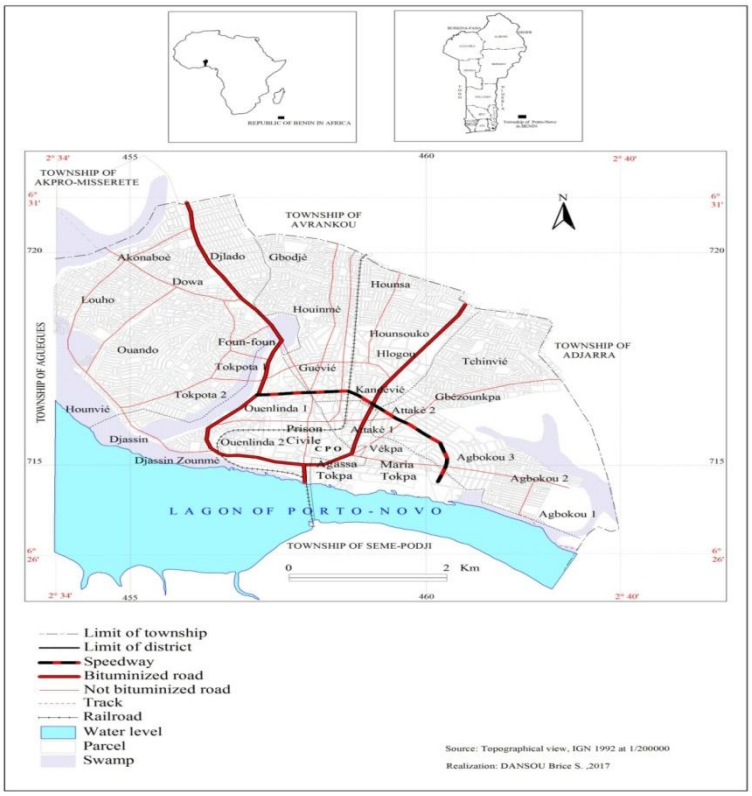

Figure 1: Location of the city of Porto-Novo

The city of Porto-Novo is located between 6 ° 26 'and 6 ° 31' north latitude and between 2 ° 34 'and 2 ° 40' east longitude. It is located in the south-east of Benin, 32 km from Cotonou and is bounded to the north by the communes of Akpro-Missérété, Avrankou and Adjarra, in the south by the commune of Sèmè-Kpodji, in the East by the municipality of Adjarra and in the west by the commune of Aguégué. The city is made up of five districts and covers an area of 5274 hectares (Vigninou, 2010). Located on the plateau of Sakété, which rises gradually as one moves away from the lagoon, the city of Porto-Novo is built in amphitheater at an average altitude of 29 meters and is dominated by the soils weakly ferrallitic regions of the Continental Terminal bar land plate and hydromorphic soils. From a geomorphological point of view, the city of Porto-Novo is part of the coastal sedimentary basin, which comprises a set of three plateaux called plateau des southern Benin: the plateau of Kétou, the Sakété plateau and the Allada plateau (Azonnakpo, 2007). At the level of this coastal sedimentary basin, we can distinguish the plateau soils, the plateau soils, the soils of the Lama depression and the soils of the valleys and the littoral zone. To carry out the study, a methodology was developed.

II. Research Methodology

The data used in this study are quantitative and qualitative in nature. They concern the forms of recovery of waste developed in the city of Porto-Novo as well as the benefits of recycling waste to households. These data are collected from 600 households interviewed in the city of Porto-Novo. They are complemented by information gathered from recyclers, managers of recycled objects collection sites and resellers of recycled objects identified in the field. In addition, the bibliographic analysis made it possible to apprehend other experiments on the valorization of waste which can reinforce the measures in progress in the city of Porto-Novo.

In addition, interviews were conducted with 42 resource persons and observations to learn about certain aspects of waste recovery in Porto-Novo. The data and methods described have yielded results.

III. Results And Discussion

2.1 Operators of waste recycling in the city of Porto-Novo

The sector of waste recycling in the city of Porto-Novo is animated by various actors. The geographical origin of the reclaimers is characterized by ethnic diversity with a preponderance of immigrants as shown in figure 2.

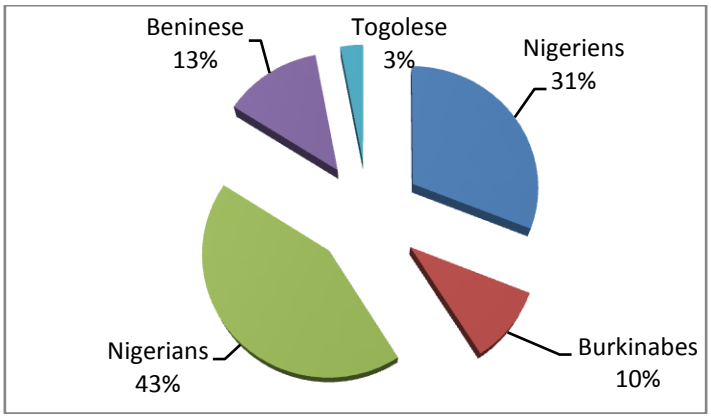

Figure 2: Geographical origin of the collectors surveyed
Source: Field surveys, February 2017

Figure 2 shows the origin of the collectors surveyed in the city of Porto-Novo. It is clear that the recovery sector is 87% controlled by West African nationals, including 31% from Niger, 10% from Burkina Faso, 43% from Nigeria and 3% from Togo, compared with only 13% of Beninese origin. According to surveys, the choice of recuperation as a trade by one or the other is motivated by various reasons, as shown in figure 3.

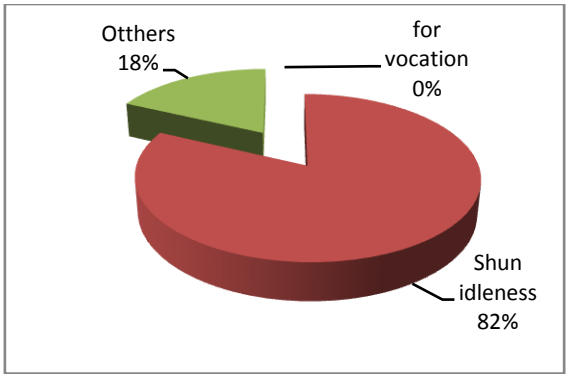

Figure 3: Reason for choosing waste recycling loom
Source: Field surveys, February 2017

Due to the society's view of waste collectors, seen as "sub-men", and the trade itself, seen as a form of begging, none of the respondents admitted to doing this activity by vocation. On the other hand, 82% of the respondents chose to practice this trade by necessity and to flee the unemployment environment. It appears that the reclaimers are young men struck by the underemployment, chronic in Porto-Novo. It is also adults who have not had the chance to go to school and who, because of the misery in which they vegetate at the family level, engage in this activity which allows them to vice, boredom, and need. Among the other reasons (18%) for the choice of the recuperator trade, the following comments were gathered in the field:

- "I am looking for money to finance my studies because I am a fourth grade student and I no longer have any support"; - *"I work here to feed my little family because the vulcanizer job I learned no longer works properly."*

Contrary to popular belief that the job of collector is only for the illiterate or those who have not been able to emerge at school, these answers prove that this activity also welcomes pupils who other categories of persons seeking means to finance their needs (study, family responsibilities, etc.).

2.2 Principal solid wastes recovered in the city of Porto-Novo

This section describes the types of waste being recycled and the uses that are made of it.

✓ **Typology of the main waste recovered**

Valuation here takes two forms essentially: self-recovery and re-use or re-use. They allow a first reduction at the source of the quantity of waste generated by the activities. Three main reasons justify the option of recycling waste. These include immediate subsistence, resale, and scientific or artistic use.

Wastes with immediate reuse are usually edible waste, such as food scraps, discarded products. These products are intended to be consumed soon after. As for wastes destined for resale, they include many discarded items that can regain a market value at little cost, and thus provide a means of existence. This is the case, for

example, with glass or plastic bottles or metal objects. According to Dossou-Yovo (2013), this type of use remains the dominant form of recovery in developing countries. Finally, waste for "professional" use: this case remains extremely marginal compared to the other two; it mainly concerns the recovery of waste made for an artistic creation for example. Table I lists the uses made of waste recovered in the city of Porto-Novo.

Table I: Directory of Recovered Waste and Different Uses

Waste recovered	**Uses**
Waste glass	
Bottle, jars	Reclaimed from reclaimers and reused for food preservation
Broken glass	Used as "anti-theft" to bristle the walls, flower bed decorations
Metal Waste	
Pins, needles	Recycled as seamless
Falling metals	Reclaimed to recoverers for recovery
Wrenches, nuts, bolts, nails	Retrieved as reclaimed or reused as spare parts
Canned cans and cans of beverages	Reclaimed from reclaimers and reused for food preservation
Ferrous metals	Reclaimed for valorization (manufacture of lanterns, molds of cakes, gutters seals, basins, etc.).
Non-ferrous metals (aluminum)	Reclaimed for recoveries for recovery (ladle manufacture, pans, stoves, clutch cages, rims, gearboxes, etc.)
Empty paint boxes	Used as seal or container
Bicycle parts, auto parts	Sold as is or reused as spare parts or in decorative crafts
Cooking utensils	Reclaimed to recoverers for recovery
Bottle Caps	Used in Utility and Decorative Crafts Returned to recoverers for recovery
Inert waste	
Tiles, broken earthenware	Reused in the construction of houses
Food waste	Food and feed
Wood waste	
Branches, wood chips, shavings, ribs	Reused in the construction of houses, the manufacture of furniture or as culinary fuels or litter for animals
Rubber wastes	
Worn tires	Re-used by fishermen
Worn shoes	Reused by shoemakers
Vegetable waste	
Leaves and corn cobs	Used as fuels or toilet paper
Rest of cereals and tubers, fruit, vegetables	Used as animal feed (goats pigs)
Plastic and papers wastes	
Plastic bags	Used in arts and crafts Used as a source of energy
All types of paper	Used as fuels or "toilet paper" Food packaging
Plastic shoes	Retail in Nigeria for the production of recycled plastic
Other	
Drain oil	The oil is used to lubricate gears, to fight animal scabs (especially sheep), to combat the odors of traditional toilets, etc.

Source: Field survey, 2017

Table I shows that all types of waste can be recovered. The type and quantity of waste recovered are linked to several factors: the market demand, the level and the way of life of the consumers, the level of trade in recycled raw materials, and so on. However, it is in the area of renovation valuation that the main outlets exist.

- **Some sub-sectors of waste recovery**

There are two ways of recovering waste when they are not directed to a final discharge (controlled or not). This involves material recovery (reuse, recycling reuse) and energy recovery.

- **Recovery of metal waste**

In Porto-Novo, the craftsmanship of recovery and recycling is quite developed and takes place mostly in an informal setting. The recovery of metals takes essentially two forms: recovery and reuse. There are other sub-sectors of metal recovery including tinsmithing, casting, and recovery and sale in the state.

- *Tinsmithing and foundry*: Tinsmithing transforms objects such as cans, bottle caps, etc ... into various objects such as lanterns, gutters, kitchen. It also offers services such as repairing tin containers (seals, basins), making gutters. As for the foundry, it most often transforms aluminum and sometimes zinc, bronze and other metals into products often used in domestic work (pot, ladle, pans, stoves, ...). It offers repair services of old casseroles and the manufacture of certain motorcycle parts. More and more it produces new imitation products such as "gearboxes", motorcycle clutch cages (plate 1).


a

b

Plate 1: Kitchen (a) and pots (b) made from recycled metals in Porto-Novo
Shooting: Dansou, avril, 2017

Plate 1 presents various kitchen items that are made with recycled metal objects. Tinsmithing and foundry are activities carried out by many young people in Porto-Novo.
- *Recovery and sale in the state*: the sale of irons is growing in the city of Porto-Novo. In general, young people with rickshaws storm households, garbage dumps and garages looking for used irons that have become valuables. They pick up these objects from the dumps or buy them and then send them to regroupment sites (plate 2).


a

b

Plate 2: Scrap metal plant in Tokpota (a) and Atakè (b) in Porto-Novo

Shooting: Dansou, March 2017
Plate 2 presents a scrap grouping site located in Atakè and Topkota. This site has a workforce of about 25 people. The latter are hierarchical, from the collector on deposit or door to door, to the sorters and dealers who sometimes export the materials to Nigeria. This is the case of metals that are processed in the metallurgical industry and used plastic shoes that are reintroduced into the plastic industries or are reworked in shoe manufacturing units.
Recovery is an activity that provides the hard worker with professional income to improve his living conditions.

Figure 4 shows the average incomes per day of the collectors surveyed.

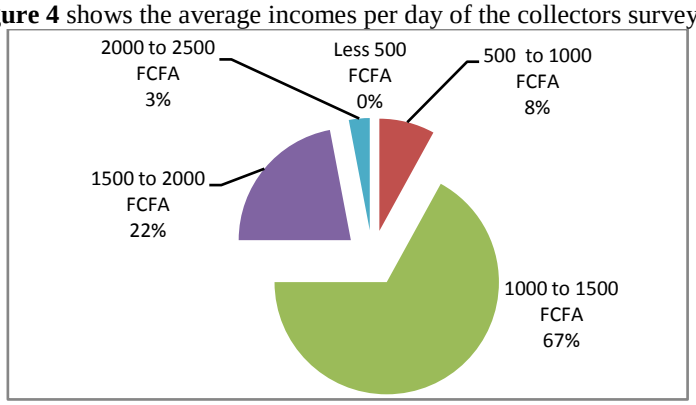

Figure 4: Daily Average Recovery Income
Source: Field surveys, February 2017

Figure 4 shows that 67% of collectors surveyed have a daily income ranging between 1000 and 1500 F CFA, 22% have a daily income between 1500 and 2000 F CFA, 8% of the collectors met manage to make a daily recipe between 500 and 1000 F CFA while 3% make a daily receipt between 2000 and 2500 F CFA. Considering 1250 F CFA as a basic average income, a dedicated salvager can easily raise a monthly salary of about 37,500 F CFA corresponding to 30 working days. This sum is very close to the SMIG in Benin, which is 40,000 F CFA. This activity is more profitable in Cameroon where Tchikoua (2010) has shown that an assiduous and professional recuperator can easily total a monthly salary of about F CFA 60,000, double the Minimum Interprofessional Growth Wage. According to 100% of recoverers, this activity nourishes his man. However, there is no official data on the functioning, the actors, the structuring, the networks and the socio-economic participation of this sector in the life of the community. The authorities would benefit from being more attentive to sectors such as the recovery sector, which, although presently in the informal sector, still employs a large number of young people and, in turn, feeds many families. The structuring and scrupulous follow-up of the recovery sector would make it possible to employ more people and could constitute a source of revenue for the municipality. In the city of Porto-Novo, there were five scrap metal clustering sites with an average workforce of 20 people. In 2002, nearly 12 kg of metal waste was collected per day by each collector (Dorrier-Apprill et *al.,* 2002). Nowadays, in view of the multiplicity of scrap grouping sites and recycling agents, about 8 kg of metallic objects are brought back per day per collector, ie 160 kg per day for a site. Within one week, approximately 1,120 kg of metallic object is recovered at each site, ie approximately 5,600 kg per week for the five sites. Eighty percent of the stakeholders interviewed also want to reorganize the sector in order to contribute significantly to the development of the city of Porto-Novo. This involves setting up a platform for actors in the recovery sector-local authorities in order to equip the players with the means to create local companies capable of transforming the recycled objects on the spot instead of exporting them to Nigeria.

- **Recovery of plastic waste and glasses**

Plastics and glass recovery activities have expanded considerably in recent decades.

- *Plastic waste marketing, a means of fighting poverty*

The difficult economic context faced by several households in the city has encouraged the development of a new economic activity: the sale of plastic waste. The change in the perception of the waste has allowed it to confer an economic value (Maystre, 1994). Waste becomes a profitable good and promotes the development of an income-generating activity. In practice, collectors collect waste plastic waste: sachets, buckets, plates, basins, shoe, etc. (board 3) for resale.


a


b

Plate 3: Various plastic waste collected by city dwellers and stored in Foun foun Tokpa (a) and Kandévié (b)
Shooting: Dansou, February 2017

Plate 3 shows stocks of plastic objects collected from landfills in the city of Porto-Novo. The selling price is on average F CFA 250/kg. This activity, in addition to being ecological, is economically profitable for the collectors because it allows several of them to be able to support themselves with the money obtained.

This recovery action practiced largely by low-income populations or poor children is often risky. Populations that sort garbage at garbage or dump sites expose themselves to cuts of sharp objects, infections, insect bites or animal bites. Once these sorters have a certain quantity, they sell them to the waste buyers according to the state of wear and cleanliness. This experience is somewhat improved in Burkina Faso (Ouédraogo, 2015). As part of the implementation of the national strategy to reduce plastic waste in Burkina Faso, in May 2014, the Government of Burkina Faso launched an extensive campaign to purchase plastic waste on the Kilogram. The price of 125 F CFA / kg fixed does not take into account the quality of the packaging. This remuneration motivated several people to get involved in the collection of this waste. This activity enabled

several of them to be able to meet their needs with the money obtained and to collect large volumes of waste and especially plastic bags (Ouédraogo, 2015). This operation allowed to collect in one day 5 tons of plastic waste in Dakola and 3 tons in Koubri. This activity also generated about 1,000,000 F CFA for the collectors of these two localities (Ouédraogo, 2015). This experience can be applied in Benin in general and particularly in the city of Porto-Novo. The collected plastic waste can be used as raw material for structures such as the AGRIPLAS plastics recycling center of the NGO DECAM-Bethesda. In Porto-Novo, apart from the commercialization of plastic objects by private individuals, there is the NGO "Qui dit mieux" which has been illustrated in the valorization of plastic bags. - *Transformation of plastic bags by the NGO "Qui dit mieux"*

The NGO "*Qui dit mieux*" was founded in 1980 and has started its activities of valorization of plastic bags in the city of Porto-Novo since 1997. This valorization translates into the manufacture of various objects such as bags, dolls and other objects (plate 4).

a b c

Plate 4: Dolls (a), shopping nets (b) and handbags (c) made by the NGO " Who says better " in the city of Porto-Novo

Source: http://courantsdefemmes.free.fr accessed the 09 August 2017 at 15h

Plate 4 presents some objects (dolls for children, shopping nets and handbags) resulting from the valorization of plastic bags by the NGO "Qui dit mieux" in the city of Porto-Novo. The NGO produces a doll with 50 sachets or a handbag with 300 sachets. The production of a bag net consumes 80 large bags and 25 small bags. On the other hand, the manufacture of a backpack consumes about 300 large sachets. The average monthly turnover of the NGO is estimated at 2 000 000 FCFA approximately (The post.fr).

The treatment and recovery process is fairly simple and includes the following main steps: recovery of bags (as well as flexible plastic waste) by various waste collectors, washing of recovered waste, drying of wastes, sorting by size and by color and finally, cutting and then crocheting (CREPA, 2011).

According to a former employee of the NGO met, the organization is struggling to sell its products in Benin and the sub-region due to lack of financial support. In spite of these difficulties, the NGO's efforts had been rewarded with the United Nations Prize for Poverty Reduction and Environmental Protection, which the NGO president had received in 2002 (http://courantsdefemmes.free.fr). But the NGO stopped its activities because of the death of the president and the persistence of financial difficulties. The involvement of local authorities in the resumption of this activity is essential because it contributes to the improvement of the living environment and the creation of jobs.

- *Marketing of plastic bottles and glass bottles*

In the city of Porto-Novo, plastic bottles are most often recovered and sold for re-use. They are displayed in markets, in shops or at home (plate 5).

a b

Plate 5: Plastic bottles recovered and offered for sale at Ouando market

Shooting: Dansou, February 2017

Plate 5 shows the plastics recovered and ready for reuse. Once empty, the plastic bottles are either sold free to the collectors or sold sold between 10 CFA francs and 25 CFA francs per unit (depending on its condition and capacity). They are then washed and resold between 25 and 50 CFA francs per unit in the trade. These recovered objects come to life and are used in the preservation of petroleum or detergents (liquid soap, cresyl), food products (crushed pepper, spices, peanut oil, red oil, fruit juices, etc.).

When it comes to glass bottles, recovery is also booming. This is probably due to the fact that Benin does not have a glass production plant (Dossou-Yovo, 2013). In Porto-Novo, the recovered glass is returned to clean for use. The bottles are sold to collectors called "Gohoto" between 20 F CFA and 50 F CFA the unit (according to its state and its capacity). They are then washed and resold between 50 F CFA and 150 F CFA the unit in commerce. A "Gohoto" who buys an average of 60 bottles at 50 CFA francs per unit and resells them at 75 CFA francs the unit makes a profit of 1500 CFA francs. These bottles are used in the preservation of beverages, agri-food products, petroleum products and pharmacopoeial products. Notwithstanding the economic value of this activity, the use of products resulting from the recovery of waste, is also to "monitor more closely". This is particularly the case for the conditions for the reintroduction of packaging and other bottles recovered on the market. Some of them previously used to condition chemicals or toxic substances are directly returned to the market after a simple "washing", posing certain risks for consumers, in particular drinks and other food products packaged in these containers. The hazards associated with the informal trade in containers and other bottles are real, including the risk of contact poisoning of foodstuffs with containers previously used as containers for chemicals and / or poisons (pesticides). These are bottles containing bleach, pesticide drums or drums, and re-used engine oil cans, which are sometimes re-used to package various food drinks and liquids (palm oil or peanut oil, milk ...).

- **Recovery of pneumatic wastes, paper and inert materials**

- Pneumatic wastes: The pneumatic wastes recovered are the inner tubes used for the manufacture of lugs and bike tensioners sold respectively at 800 CFA francs and 300 CFA francs per unit. These objects are commonly used in households. Tires are also used in restaurants to serve as a table (photo 2) or are used to make joints and serve to delimit a space. They are also used in the manufacture of shoes (photo 1).

Photo 1: Shoe manufacturing workshop using pneumatic waste and used shoes in Agbokou
Shooting: Dansou, February 2017

Photo 2: Barrels and user tires used as table at the amusement park "Le Légendaire" in Porto-Novo
Shooting: Dansou, February 2017

Photos 1 and 2 present the forms of recovery of pneumatic waste in the city of Porto-Novo respectively. The manufacturing workshop (photo 1) employs five workers and manufactures a varied range of sandals from pneumatic wastes collected from landfills and households. The selling prices of shoes range between 1000 F CFA and 3000 F CFA per unit. About five shoes of 1500 F CFA units per unit are sold per day which is a monthly gain of 225,000 F CFA. Although these are rare experiences in Porto-Novo, they deserve to be accompanied and multiplied because they help to improve the living environment. Moreover, it can constitute a source of revenue for the town hall because at the moment this activity escapes tax. Pneumatic wastes are also used in restaurants where they are used as furniture (photo 2). This on-going experience in this amusement park can be extended in homes and especially in gardens. This will considerably reduce this type of waste.

- *Papers:* In the city of Porto-Novo, used piles of newspapers, reports, bags of cement, etc. are sold in retail at an average of 25 F CFA to merchants to pack bread, grilled peanuts and so on. The recovered paper is also very often re-used for the packaging of vegetables, fruits or sweets despite the risks presented by this practice. According to Diawara (2010), unwanted newspapers or old newspapers, whether originating from the initial domestic monostockage or purchased from printers, often contain toxic substances used in the process of making or printing magazines. The use of printed paper for the packaging and transport of food should be tolerated only for foodstuffs which are to be prepared before consumption (fruit and vegetables to be peeled etc.). - *Inert materials*: Unlike other types of waste, inert materials are poorly recovered in the city of Porto-Novo. They are essentially made of broken porcelain and used in the construction and especially in the coating of the floor and walls.

- **Energy recovery of waste in the city of Porto-Novo**

The energy recovery of waste is observed very little in Porto-Novo in general and in households in particular. There is, however, the experience of the Songhai Center which deserves to be popularized (figure 5).

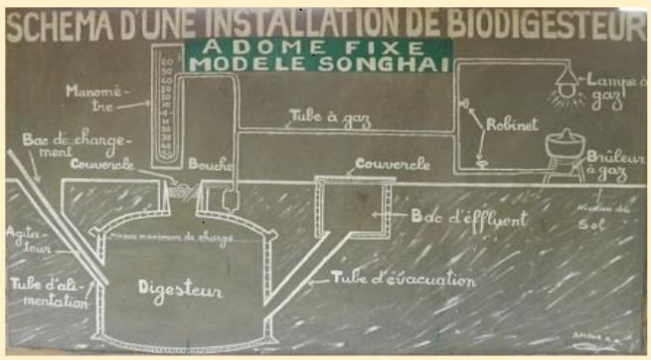

Figure 5: Diagram of a bio digester installation

Source: do-Régo, 2017

The device presented in Figure 5 shows the diagram of a bio-digester at the Songhai Center in Porto-Novo. This system of transformation of organic waste into energy usable for various sources is presented as follows:

- the loading of the waste into the digester which undergoes a chemical transformation;
- this waste is transformed into gas (CH4) after several chemical transformations. It is this gas which is used for the supply of energy, usable for different needs and services in the center. This mechanism is done by a connection of pipes and taps to the digester for the supply of energy.

This system can be implemented in the outlying districts of Porto-Novo which are poorly served by electricity and in public places such as bus stations and markets. There is also an integrated mechanism at the Songhai Center for the recovery of waste from plant production, livestock production and fish farming. This system is based on the principles of synergy, (Interaction between three agricultural-breeding-pisciculture clusters). The integrated production system recycles and upgrades the by-products (waste) of the production units and the farm in general. This model brings many technical, ecological, economic and social advantages and deserves to be popularized by the municipal authorities. Unlike solid waste that is recovered in the city of Porto-Novo, excreta is rarely used. The mechanically emptied sludge is evacuated by the drainers to the dumping sites located in the 2nd district. They are then used by some market gardeners to improve the soil. This strategy deserves to be improved for ecological management of excreta. Moreover, there are strategies for waste recovery in Porto-Novo. However, there are also various waste-recovery experiments that need to be analyzed in order to reinforce those existing at Porto-Novo.

3.4 Analysis of solid waste recovery experiments

There are several strategies for recycling waste in the world. In Benin, some structures are illustrated in waste recovery. They are the NGO DECAM-Bethesda, the Polytechnic school of Abomey-Calavi University and the ValDERA center at the University of Abomey-Calavi.

- ✓ **Experiences of the NGO DECAM-Bethesda in Benin**

Since 1994, the NGO DECAM-Bethesda has made a name for itself in the production of compost and later in 1999 in the recovery of plastic waste.

- *Composting of solid household waste*

The NGO DECAM-Bethesda has a sorting center for solid household waste composting on a six-hectare site in Hèvié in the commune of Abomey-Calavi. From biodegradable materials, the NGO shall:

- composting by the aerobic windrowing system. This technique consists in putting in place a layer of biodegradable waste on a ground covered by waxed cloths recovered in the waste. This first layer is watered and receives an injection of animals. A second layer is then laid. These two layers reach about 1.20 m high with an average volume of 30 m^3. This pile is returned each time for three months. The product obtained at the end of the three months is compost. It is then bagged and sold at 1500 F CFA the bag of 50 kg.
- production of potting soil. After sorting, the residual mixture of sand and debris is stored for six to nine months, where it undergoes a decomposition phase. After sieving, the mixture obtained produces potting soil which is sold at 2000 F CFA per cubic meter, ie about 200 kg.

- *Valorization of plastic waste*

The plastics recycling center, called AGRIPLAS, was founded in 1999 to collect plastics waste such as films and rigid plastics in PE, PVC or PP, recycling itself and marketing the products obtained. This technique, known as regeneration, involves the production of powder, granules or ground material from plastic waste, comparable to virgin resins, and reintroduced into the international market for plastic resins (Bruneau, 2015). At DECAM-Bethesda, some of the pellets and crushed raw materials are used as raw materials for the plastic manufacturing industries in Nigeria and Ghana. The rest of the pellets and grinders are transformed into electric and pellet sheaths and sold on the local and sub-regional market (CREPA, 2011).

In Senegal, particularly in Thiès and Dakar, the regeneration technique is used by the PROPLAST unit (Bruneau, 2015). This unit employs 140 employees and temporary workers, and values around 100 tons of hard plastic (PP, PE) each month, which is crushed or extruded (Bruneau, 2015). These plastics are purchased between 75 and 100 CFA francs to a thousand collectors based in Thiès and Dakar.

It would be interesting for the experience of the NGO DECAM-Bethesda in Benin and PROPLAST in Senegal to be disseminated to the economic operators of the city of Porto-Novo. They can invest in this sector and create green jobs for youth.

✓ **Experiences of the Polytechnic school of Abomey-Calavi University**

At the end of the 1990, the idea of using plastic (notably plastic bags) as a binder to replace cement was used to produce different building elements such as pavers, bricks, tiles (Bruneau, 2015). In Benin, research work is being carried out by teachers and researchers at the Ecole Polytechnique of the University of Abomey-Calavi on the problem of the recovery of solid waste. In this school, studies have been conducted on the recycling of plastics as an additive in molten-plastic composites, and other studies on the valorization of plastic wastes in construction. Among the results obtained by these researchers, there is the manufacture of household items (towels, carpet for machine support, etc.) (CREPA, 2011). This form of valorization has the advantage of requiring low investments and makes it possible to upgrade the bags.

✓ **Other recycling experiences of plastic waste**

According to Madam (2003), used products (bottles, used shoes, plastic bags etc.) are also used to make ashtrays, garbage cans, road signs, various decorative objects, teaching materials and so on. The production technique is summarized as follows (Doublier, 2009):

- waste sorting, which is intended to remove impurities, to store waste according to color and material;
- a weighing of the waste to ensure that the weight of plastic material required for manufacturing is reached;
- a fusion of the waste to obtain a material in replacement of the cement;
- a manufacture of the object by means of the binder obtained.

According to Lukambil quoted by Ouedraogo (2015), a pavement with 20 kilograms contains 977 plastic bags. As such, a road 12 meters wide and 1000 meters long has 12000 m². However, 1 square meter contains 32 pavers. This means that for 12,000 m², we will have 384,000 paved and consumed about 384,000 tons of sachets since a block corresponds to 1kg of bags. Therefore, the construction of 384,000 pavers will be able to destroy more than 384 tons of bags. "These pavers are used to beautify living spaces: houses, services, gardens, etc. and significantly reduce the volume of waste in our cities.

In several other cities, different associations are involved in waste reduction. In the city of Rotterdam, experiments are under way to use plastic in the field of roads. Plastic roads have the characteristic of being more resistant over time and adapted to temperature variations (-40 ° C to 80 ° C). This recovery of plastic waste would replace asphalt (bitumen) and contribute to the reduction of greenhouse gas emissions (Malsch, 2015).

In Madagascar, the plastic bag enhancement technology has been perfected in Mahajanga with the Madacompost center (Bruneau, 2015). This center has developed an activity of production of bricks and paving stones based on plastic. Photo 3 shows a latrine constructed from sand-plastic bricks.

Photo 3: Latrine constructed from sand-plastic bricks in Mahajanga in Madagascar
Source: www.plateforme-re-sources.org

Photo 3 shows a latrine constructed with plastic bricks manufactured at the Mahajanga waste recycling center. With a team of 6 workers and 4 cast iron reactors, this center can produce up to 7m² of paving stones per day (Bruneau, 2015). This activity allows the recycling of 80 tons of plastic per year, ie 1.4 million bags.

This Malagasy experience can be applied in the city of Porto-Novo. To this end, municipal authorities must establish a South-South partnership with Malagasy ones so that feasibility studies can be carried out. An emphasis should be placed on the inter-communality between the city of Porto-Novo and the other communes of the Ouémé and Plateau departments in order to pool the financial resources necessary for the installation and management of the infrastructure as well as the supply of plastic waste.

Moreover, considering the importance of plastic waste in Beninese cities and the benefits that flow from their development, it would be interesting to have the production of plastic pavers supported and financed by the administrative authorities and financial institutions. Through the production of cobblestones and the manufacture of utility objects, it would considerably reduce environmental damage and could create jobs for a part of the population. These various valorization actions make it possible to give a new life to plastic and to extend its usefulness for society.

- ✓ **Experience of energy recovery of biodegradable waste at the ValDERA center of the University of Abomey-Calavi**

For the valorization of waste to become a reality in the city of Porto-Novo, the ValDERA center at the University of Abomey-Calavi must be involved. At the ValDERA center, the process of recycling household waste consists of four main elements:
- the installation of an improved bio-digester to optimize the results;
- methanisation of liquid and solid wastes;
- the conversion of biogas into electrical energy;
- the agricultural yield of digestate and household waste.

The objective of the establishment of the bio-digester of the ValDERA Center is to:
- optimize all types of biodegradable waste;
- to produce biogas for heat, lighting and electricity;
- to promote an alternative, renewable, clean and adapted energy source adapted to stress situations, using bagasse and other fermentable wastes;
- to propose innovative and optimized solutions for the start-up of the anaerobic digester, the production and use of biogas.

It is a device composed of organic waste, water, bacteria, without air; which produces biogas and allows a solid amendment accompanied by liquid fertilizer. The principle of biogas allows the production of an overall ecological energy. Biogas technology is an innovation for sustainable development because urban waste (sewage sludge and household refuse), waste from livestock and agricultural production, industrial waste treated by methanisation produces renewable energy in the form of biogas be transformed into heat, electricity and vehicle fuel, as well as a high-quality agricultural amendment. Biogas technology plays an important role in improving the quality of life of households. It facilitates access to clean, less expensive energy through the valorization of animal waste. In terms of energy, the calorific value of the biogas is about 6 kWh / m3, which corresponds to about 5.5 kg of firewood. The total combustion of 1m3 of methane can reach a temperature of 1400 ° C and produce a heat quantity varying between 8562 and 9500 kilocalories (Seibou Idrissou, 2016). Thus, the combustion of one cubic meter of biogas can produce energy between 5500 and 6500 kilocalories.

At the health level, biogas is a factor in improving hygiene and health conditions. Its use reduces smoke-related diseases (headaches, eye infections, respiratory infections, etc.); absence of soot, ashes and wood in the kitchen and the fall in fire accidents (Seibou Idrissou, 2016).
The use of biogas also contributes to:
- Reduction in the time taken by women and children in particular for domestic work such as collecting wood, preparing meals and cleaning;
- the considerable improvement in the quality of the education of children through the opportunity offered by the availability of a biogas lamp;
- the creation of jobs and income for the different categories of actors working in this new technology.
Biogas is also a stimulus for agricultural production because it makes it possible to combat soil depletion. One cubic meter of effluent corresponds approximately to:
10 kg of ammonium sulphate;
- 4.5 kg of super phosphate;
- 10 kg of sulphate of potash;
- other fertilizing elements.

Biogas also offers environmental benefits because it contributes to reducing deforestation by reducing fuelwood consumption and reducing erosion. It is most often used for cooking food. The complete installation of a family production of biogas requires only 10 days of work and does not present any difficulty except for a perfect watertightness of the tank. It is also useful in lighting houses. Indeed, according to Seibou Idrissou (2016), there are biogas lamps for individual or community lighting. They are generally lamps with sleeves similar to those with oil under pressure; which provides the same illumination as that of a 60 W incandescent lamp.

In Benin in general and in the city of Porto-Novo in particular, the problem of energy arises with acuity. The experience of producing biogas at the ValDERA center is an opportunity for the city to ensure its energy autonomy. Similarly, biogas can also be used as fuel in a stationary engine for the production of motive power or a generating set for the generation of electricity. With the energy deficit observed in Benin and in the city of Porto-Novo, the promotion of electric generators, using biogas, will contribute to the reduction of this deficit. To this end, the ValDERA center can serve as a lever for people and also for state structures.

3.5 Measures for ecological sanitation of excreta in the city of Porto-Novo

The proper management of excreta requires the use of ECOSAN latrines in view of the limits of collective sanitation systems (Totin et *al.,* 2008, McCarty, 2008). Figure 7 shows an ECOSAN latrine with a heating plate.

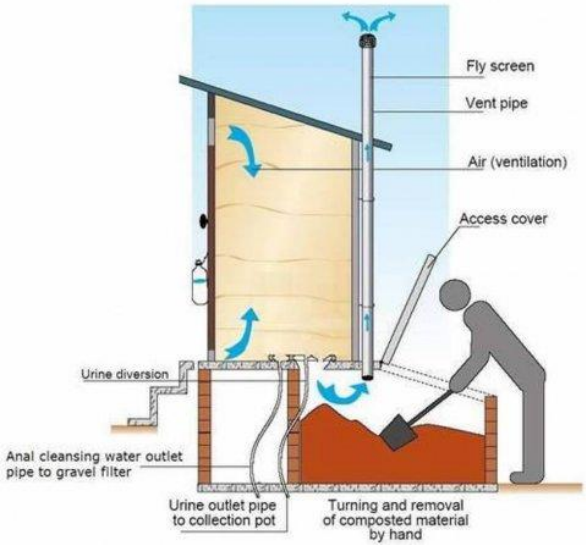

Figure 7: ECOSAN heated griddle

Source: Adamou, 2010

There are the Vietnamese type double-pit ECOSAN latrines (LEDF) and the ECOSAN latrines with Tec pan heating plate (LEPC). The specificity of Vietnamese double-pit latrines is that the drainage doors are lateral, whereas in the latrines of the Tec pan type, the drain panels behind are oriented at an angle of 45 degrees to the sun for increase the temperature and drying of faeces in the pits. It would be interesting to have this system popularized because it has advantages.

- Environmental benefits

ECOSAN latrines reduce odors, provide a clean and healthy living environment. If ecological sanitation could be adapted on a large scale, it would protect surface water and groundwater from fecal contamination. They offer ease of construction above ground (CREPA-SIEGE, 2005).

Eco-sanitation makes it possible to use urine as a high-value fertilizer. This would reduce fertilizer costs and increase crop yields. The 400 to 500 liters of urine produced by each individual for one year contain enough nutrients to grow 250 kilograms of grain sufficient to feed a person for one year (Schonning et *al.*, 2004). The urine is rich in nitrogen, phosphorus and potash. It contains 90% value in human excreta fertilizer. The urine should be diluted with water and placed directly in market gardens and agricultural fields or stored in underground tanks for later use (Jönsson et *al.*, 2005).

- Benefits for households and neighbors

Eco-sanitation systems, if correctly managed and maintained, produce no flies or other insects because moisture levels are too low to generate flies. This is a big advantage over ordinary pit toilets. At the health level, ECOSAN latrines reduce the incidence of infections due to hydrofecal diseases.

IV. Conclusion

This survey diagnosed the strategies for valorization of solid waste in the city of Porto-Novo in Bénin. The gotten results showed that several strategies are used to upgrade the waste in Porto-Novo. In addition, this activity generates income for the different people who practice it. These revenues make it possible to satisfy their different needs. In the same way, it helps to rid the city of those objects which, poorly managed, are a source of nuisance. The experiences that exist in the other cities of Benin and in the world deserve to be adapted to the realities of the city of Porto-Novo in order to create more stuff for the youth. To this end, research teams must be set up so that in-depth studies can be made on the problem of waste recovery. Also, the various initiatives must be supported financially to promote ecological management of waste.

Bibliography

[1] Adamou A.K., 2010. Étude sur la viabilité socio-économique de l'approche EcoSan au Niger : (Sites de Torodi, Aguié et Madaoua). Mémoire de master spécialisé en Génie sanitaire et environnement, 2iE, 64 p.

[2] Azonnakpo V. O., 2007. Problématique de l'eau et de l'assainissement en milieu scolaire en République du Bénin : cas de la ville de Porto Novo, Mémoire de DESS en décentralisation et gestion des eaux, UAC, consulté sur www.memoireonline.com le 31/10/2016 à 22h 18min

[3] Bertrand J-R. et François L., 2003. De la décharge à la déchèterie. Questions de géographie des déchets. Presse Universitaire de Rennes, 175 p.

[4] Bruneau M., 2015. Recyclage des déchets plastiques dans la gestion des déchets en Afrique et dans les caraïbes : présentation synthétique de l'état des lieux et des retours d'expériences, Plateforme re-sources, www.plateforme-re-sources.org, 6 p.

[5] CREPA, 2011. Etude sur la gestion des déchets plastiques dans l'espace UEMOA cas du Bénin. Rapport final, 59 p.

[6] CREPA-SIEGE, 2005. Rapport d'étude sur le gain socioéconomique de l'investissement dans l'assainissement au Bénin, 59p.

[7] Diawara A. B., 2010. Les déchets solides ménagers à Dakar. Environnement, société et gestion urbaine. Thèse de doctorat, Université de Bordeaux 3, 791 p.

[8] do-REGO T.A.F.H., 2017. Problématique de la gestion des déchets organiques dans la commune de Porto-Novo, mémoire de maîtrise, DGAT/FASHS/UAC, 77 p.

[9] Dorier-Apprill E., Agossou N., Barbier J-C., Domingo E. et Tchibozo F., 2002. Gestion des déchets urbains et aide à la décision municipale : Municipalité de Mopti (Mali) et Circonscription Urbaine de Porto Novo (Bénin), Volume III : Gestion des déchets et assainissement urbain à Porto Novo (Bénin), 133 p.

[10] Dossou-Yovo A.C., 2013. Activités économiques de rue et gestion des déchets à Cotonou (République du Bénin). Thèse de Doctorat Université d'Abomey-Calavi, 362 p.

[11] Doublier G. 2009. Valorization des déchets de sachets plastiques Utilisation comme liant dans la fabrication de matériaux composites : Application dans les villes subsahariennes» Conférence Internationale sur la Valorization des Déchets et de la Biomasse Résiduelle dans les Pays en Développement, 9-11 Juillet 2009 – Ouagadougou, Burkina Faso, 6 p.

[12] Gbinlo R. E., 2010. Organisation et financement de la gestion des déchets ménagers dans les villes de l'Afrique Sub-saharienne : Cas de la ville de Cotonou au Bénin, Laboratoire d'économie d'Orléans, Thèse de Doctorat 237 p.

[13] Jönsson H., Baky A., Jeppsson U., Hellström D., Kärrman E., 2005. Composition of urine, faeces, greywater and biowaste for utilisation in the URWARE model. Sweeden, Chalmers University of technology, 49 p.

[14] Malsch, 2015. Sur les routes, le plastique pourrait bientôt remplacer l'asphalte, www.urbanews.fr, Magazine, Aménagement du Territoire, consulté en juin 2015 à 12h 00min

[15] Maystre R., 1994. Le compost : Gestion de la matière organique. Editions François DUBUC, Paris, 954 p.

[16] McCarty P.L., 2008. The Insidious Nature of Groundwater Contamination Groundwater Contamination - The Great Need for Protection: The Great Need for Protection. Coupling Sustainable Sanitation & Groundwater Protection. Symposium, 14-17 October 2008 Hannover, Germany, Conference presentation. 35 p.

[17] Odoulami L., 2009. La problématique de l'eau potable et la santé humaine dans la ville de Cotonou (République du Bénin), thèse unique, EDP/FLASH/UAC, 230 p.

[18] Ouédraogo R. U. E., 2015. Le péril plastique à Ouagadougou : pratique urbaine et préservation environnementale, Thèse de doctorat, Université de Ouagadougou, 318 p.

[19] Schonning C., Stenstrom T.A., 2004. Guidelines for the safe use of urine and faeces in ecological sanitation systems. Stockholm, Stockholm Environment Institute, 53 p.

[20] Scriban R., 1993. Biotechnologie. Edition : coordonnateurs, 4ème éd. Paris. 904p.

[21] Seibou Idrissou M. A., 2016. La communication comme outil de gestion et de valorization des déchets dans la ville de Cotonou au Bénin. Thèse de doctorat, Université d'Abomey-Calavi, EDP/FLASH, 317 p.

[22] Tchikoua L. B., 2010. Gestion des déchets solides ménagers à Douala au Cameroun : opportunité ou menace pour l'environnement et la population. Université de Douala, Thèse de Doctorat, 479 p.
[23] Totin V.S.H., M. Boko, A.E. Edorh, 2008. Groundwater Pollution in Shantytowns of Cotonou: Which Strategies to Limit Waterborne Diseases Risks? Coupling Sustainable Sanitation & Groundwater Protection. Symposium, 14-17.
[24] Vigninou T., 2010. La périurbanisation de Porto-Novo : Dynamiques et impacts environnementaux. Thèse de Doctorat unique. Université d'Abomey-Calavi, Cotonou, Bénin, 370 p.
[25] Yémadjè A. A., 2015. Décharges incontrôlées dans les arrondissements d'Abomey-Calavi et de Godomey : Impacts sur les sols, les eaux et la santé humaine. Thèse de doctorat unique, EDP/FLASH/UAC, 357 p.

Brice Saturnin Dansou1. " Problematic of The Valorization of Solid Waste In The City of Porto-Novo In Benin." IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) 12.3 (2018): 24-37.