Original Research Article

Issues of solid waste management and ways of recovering them at the Mfidi market in the municipality Of Ngaba in Kinshasa

ABSTRACT

Aims: This study aimed to evaluate the methods of solid waste management in the Mfidi market in order to detect the various problems and propose strategies to fight against insalubrity.

Study Design: This research consists of four parts, an introduction with literature review, a description of the study environment, the methods used and finally the results obtained.

Location and duration of the study: This study took place in the Mfidi market in Kinshasa from January 20 to May 15, 2023.

Methodology: The methodological approach was based on observation and experimentation. The quantification consisted in characterizing the waste, recovering the biodegradable organic fraction by the technique of composting. Then test the effectiveness of this compost in its application in the field.

Results: This study showed that the Mfidi market produces 4349 kg every day (i.e. 16.9 kg per seller per day). About 2913 kg of waste is of plant origin (67%), 587 kg of cardboard and paper waste (13%), 519 kg of plastic waste (bags and bottles) (12%), 191 kg of metals (4%) , 74 kg of textiles (2%), 66 kg of glass waste (2%). The organic fraction was recycled into compost, whose contribution to soil fertility was justified by the growth of the species *amaranthus hubridus sp*.

Conclusion: The Mfidi market produces huge quantities of waste, 80% of which represents the biodegradable (organic) fraction. The latter made it possible to obtain compost at a proportion of 59% after three months of treatment. The compost obtained meets the standards for use as a soil amendment.

Keywords: Solid waste management, recovery, treatment, Compost, Mfidi market.

1. INTRODUCTION

For centuries, the environment has been considered by man as an inexhaustible, free, eternal good. Today, it is a costly, exhaustible, fragile asset, threatened with extinction, which requires special attention from its everyday manager: "man", who remains responsible for the many disasters that the environment is experiencing [1]. In fact, man continues not only to produce economically, but above all, to generate enormous quantities of waste whose management poses serious difficulties of collection, evacuation, sorting, treatment, or simply the difficulty of landing them in a landfill. final sanitary as ultimate waste [2].

Indeed, the problems posed by waste are becoming topical worldwide in a global way and more pronounced in developing countries (VERSTRAETE, quoted by [3]. In the latter, the spaces of their cities experience the accumulation of mountains of wild dumps of all kinds to such an extent that their living environments become unhealthy.

In Kinshasa in general and at the Mfidi market in the Commune of Makala in particular, this problem of waste accumulation is even more accentuated. Everywhere, heaps of rubbish are observed, which give this environment the image of an unhealthy city. Here, vendors produce huge amounts of solid waste every day, which tarnishes the image of the city.

Unfortunately, waste management constitutes a real barrier in the process of cleaning up this market [4].

Due to a lack of urban culture, coupled with the irresponsibility of the state services responsible for the evacuation or management of waste, vendors live the culture of ready to throw away, right in the gutter, in the street, despite the multiple evils that these practices can cause on the one hand and the multiple possibilities of recovery or recycling which today generate jobs and income on the other hand [5,6].

Among these evils resulting from the multiple difficulties experienced by sellers in managing their waste, is the exposure of sellers and buyers to multiple health risks [7]. The whole population suffers from it, because it is victim of the diseases of dirty hands, malaria, diarrhea.

The large proportion of vendors on the Mfidi market sell biodegradable products (76%) On the other hand, those who sell non-biodegradable products represent only 24%. Regarding the method of solid waste management, 78% of vendors in the Mfidi market throw their waste in the street, followed by 14% of those who throw their waste into the gutters, while 4% throw theirs into a courtyard. of water and the same figure for those who incinerate (4%). This justifies the problems of insalubrity in the city of Kinshasa in general and the Mfidi market in particular.

1.1. Objective

The purpose of this work was to contribute to the sanitation of the city of Kinshasa through the integrated management of solid waste from the Mfidi Market.

2. STUDY SITES, MATERIAL AND METHOD

This study concerned the period from January 20 to May 15, 2023, a period of intense production of solid waste at the Mfidi market, which is the rainy season.

The total number of users at the Mfidi market is 2580, including 813 stall vendors, 1689 floor vendors, 42 shops, 9 cold rooms and 27 stores.

2.1. Methodology

The methodological approach was based on observation and description. This approach is divided into two stages: a preliminary phase and a field phase.

2.1.1. Observation

Practically, the observation consisted in carrying out an inventory of the solid waste management methods at the Mfidi market. That is to say the way in which the waste is stored, transported and/or disposed of there.

2.1.2. Collection of waste samples :

Raw solid waste from commercial activities in this market was collected for four days. The quantification of the solid waste produced was carried out by weighing in selective sorting in order to categorize each type of waste.

2.1.3. Processus de compostage

The composting concerned 14 tons of waste by the technique piled up in two windrows of 60 m^3 (L x l x h = 12 x 2.5 x 2m) and 108 m^3 (L x l x h = 12 x 4.5 x 2m). These heaps were watered 3 times a week, turned every two weeks and temperature sampling after three days, until reaching 3 months for mature compost, which yielded 8250 kg out of a total of two composted windrows, 100 kg served to enrich the soil in the cultivation of amaranths. The control soil was not amended. The rest of the compost, i.e. 8150 kg, was sold at the price of 10 dollars per 50 kg bag.

2.1.4. Physico-chemical analyzes

The physico-chemical analyzes focused on measuring the hydrogen potential (pH), temperature, conductivity, total organic carbon, humidity, phosphorus and potassium. This choice is justified by the direct implication of these parameters on the composting process.

2.1.5. Tests of compost obtained on flat agricultural strips

Among the 80 Amaranth plants presented in the experimental setup (fig. 1), 50 plants, especially those constituting the useful plot, were selected. Measurements of the length of the rods were taken to submit the study to the statistical test. The device below was applied by comparing the almond soil with the control soil.

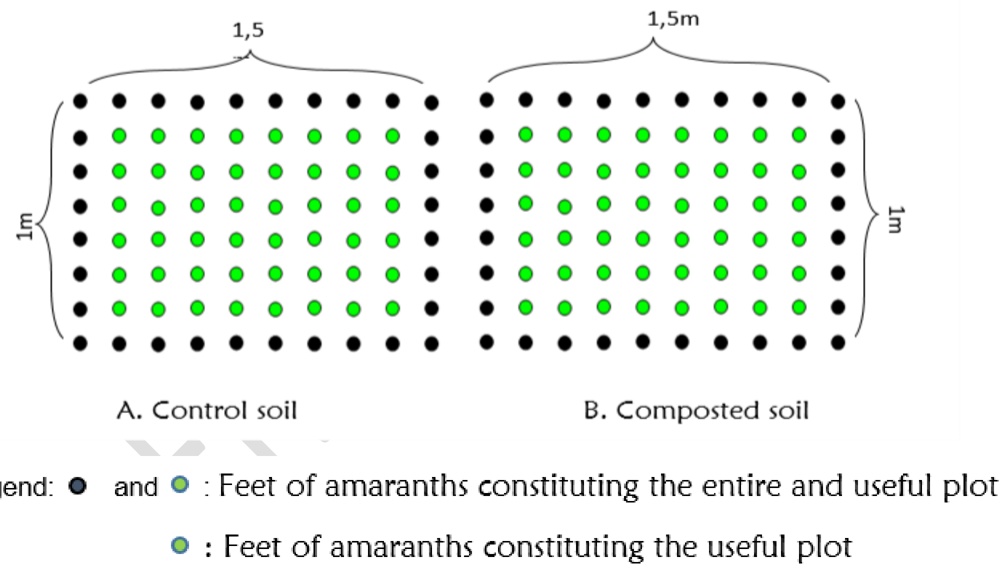

Fig. 1. (/

The entire and useful plot: concerns all 80 feet of amaranths planted in composted and non-composted soil. The useful plot: concerns 50 feet of amaranths planted in composted and non-composted soil. These are the feet that were measured for the length of the stems to submit the study to the statistical test. The Fisher-Snedecor test was used for a statistical interpretation of the results by comparing the variances of amaranths grown in composted soil and non-composted soil (control soil).

3. RESULTS AND DISCUSSION

The results obtained after these various field manipulations and experiments are presented and discussed below.

3.1. Results

3.1.1. Quantification of the waste produced per day at the Mfidi market

Table 1. Proportion of waste quantification per day and per vendor

Days		1	2	3	4	Total	Average /day	Average /day/ seller	%
Wastes (in kg)	Textiles	27	52	140	75	294	74	0,3	2
	Cardboard and paper	750	695	430	472	2347	587	2,3	13
	Plants and others	3250	3305	350	1528	11653	2913	11,3	67
	Plastics	499	525	393	657	2074	519	2	12
	Metals	205	146	198	215	764	191	0,7	4
	Glass	96	51	69	47	263	66	0,3	2
Total (in kg)		4827	4722	4800	2994	17395	4349	16,9	100

From this table, it is observed that the quantity of waste produced per day at the Mfidi market is 4349 kg. Of this quantity, 2913 kg of plant and fish waste, 587 kg of cardboard and paper waste, 519 kg of plastic waste (bags and bottles), 191 kg of metals, 74 kg of textiles, 66 kg of glass waste . In addition, it is observed that a vendor produces 16.9 kg of waste per day.

3.1.2. Composition of the waste produced at the Mfidi market

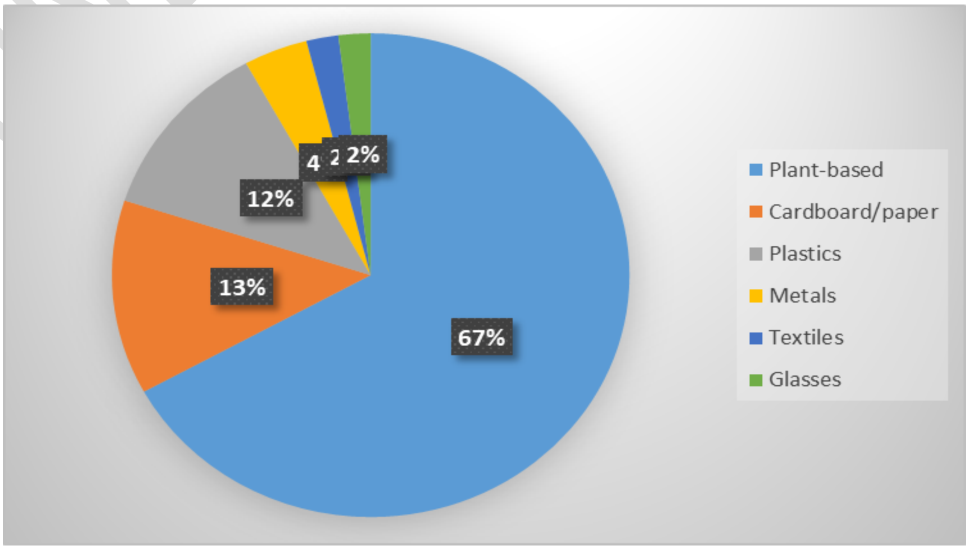

Fig 2. Synthesis of quantification of waste produced per day at the Mfidi market

This figure shows that plant-based waste is much more produced (67%) followed by cardboard and paper waste (13%), plastics (12%), metals (4%). Textiles and glasses are poorly produced (2% for each fraction).

3.1.3. Mfidi Market Solid Waste Directions.

- Plastic waste (bags and bottles) was directed towards the production of plastic pavers;

-The scrap metals were sold at a price of 250 CDF (USD 0.1$)/kg to small itinerant buyers of metals, who in turn sell them to the company Harimex which recycles metals at 17th Street, in the Municipality of Limete in Kinshasa.

- The glass waste was sold at a price of 150 CDF (USD 0.06$)/Kg to mobile buying mothers of glasses.

-The collected textile waste was simply burned. Indeed, there are no recovery alternatives for these types of waste in Kinshasa, except to dispose of them by burning them.

3.1.4. Recovery of biodegradable waste by composting

In total, 14 tons of biodegradable waste (including cardboard and paper) were subjected to aerobic composting in windrows (2 piles).
The compost obtained, i.e. a production of 8250 kg representing 59% of the initial waste, was packaged in 50 kg bags). This compost obtained had a brown color and a fresh smell.
The mature compost packaged in bags after 3 months is presented in figures 3, 4 and 5 below:

Fig. 3 and 4. Pile of biodegradable waste (left) and compost wall (right)

Fig. 5. Packaging compost in bags

3.1.5. Evolution of compost quality parameters

Table 2. Evolution of the physico-chemical parameters of the compost

parameters	Units	Values observed at the end of the composting process	Recommended values
pH	-	6,7	6,5-8,0 (Lokango, 2019 ;Toundou, 2016 ; Biey, 2019)
Electrical conductivity	µS/cm	277	< 1500 (Lokango, 2019 et Biey, 2019)
Temperature	^{o}C	26,9	< 45 or 40 (Charnay, 2005 et Lokango, 2019)

Humidity	%	52,7	40 - 65 (Kangana, 2019 ; Mikono, 2014 et FAO, 2005)
Dry Weight (Ps)	%	47,3	›à 30 (Mikono, 2014 et AFNOR, 2005)
Mg	%	0,74	0,7-3,0 et 0,5-1,4 (Mustin 1987 et castaldi et Al, 2008)
Pb	mg/kg Ps	12,7	< 180 (Mikono K, 2014 et Norme AFNOR, 2005
Zn	mg/kg Ps	43,2	< 600 (Mikono K ,2014 et norme AFNOR ,2005)
Cu	mg/kg Ps	9,0	< 300 (Norme AFNOR, 2005 et Toundou O, 2016
Mn	mg/kgPs	34,9	42,33 and 64 (Luboma M..,2007 et Toundou O, 2016
Fe	mg/kg Ps	11,0	15, 20 (Luboma M..,2007 et Alouiemine S., 2006)
Cd	mg/kg Ps	0,9	< 3 (Mikono, 2014, Biey, 2021 et norme AFNOR, 2005)
Na	mg/kg Ps	0,02	< 2 (Mulomba, 2014 and Ontario standard, 2012)
K	%	0,41	0,4-2,3 and < 3 (Toundou, 2016, AFNOR standard, 2005 and FAO, 2005)
Ca	%	2,96	2,34-3,6 and 3-12 (Mustin, 1987, Toundou 0,2016)
N tot	%	2,02	< à 3 (Compaoré and Nanema, 2016, Castaldi and Al, 2008 and AFNOR standard, 2001)
C tot	%	37,2	≥ 10(Toundou O, 2016, Youcai and Al, 2008 and AFNOR standard, 2005)
P	%	0,98	< 3 (Mulomba, 2014 and AFNOR standard, 2005)
C/N	-	18,4	15-20 and > 8 (Kolwezi, 2011, Mundele, 2016, Toundou, 2016, AFNOR standard, 2005 and FAO, 2005)

1.1.1. Evaluation de la qualité du compost par l'observation de la croissance des amarantes (*Amaranthus hubridus* sp).

The observation of the growth of the amaranths made after 21 days, shows that there is a greater improvement in terms of growth, leaf greenness and soil cover. In the composted soil, these parameters are marked with a very great intensity compared to the control soil where a simple and weak improvement was observed compared to that made on the 21st day.

The measurements of the Amaranth stems in the control and composted soil after 21 days of growth are presented in the following figures.

Fig. 6 and 7. : Amaranths on the first day in control soil (left) and compost-amended soil (right)

Fig. 8 and 9 : Amaranths after 21 days of growth in control soil (left) and composted soil (right)

Fig. 10 and 11 : Measurement of Amaranth stems in control soil (left) and composted soil (right) after 21 days of growth.

The compost used in the soil amendment for the cultivation of amaranths gave the growth results shown in Table 3, after 21 days.

1.1.2. Measurements of Amaranth stems in control and composted soil.

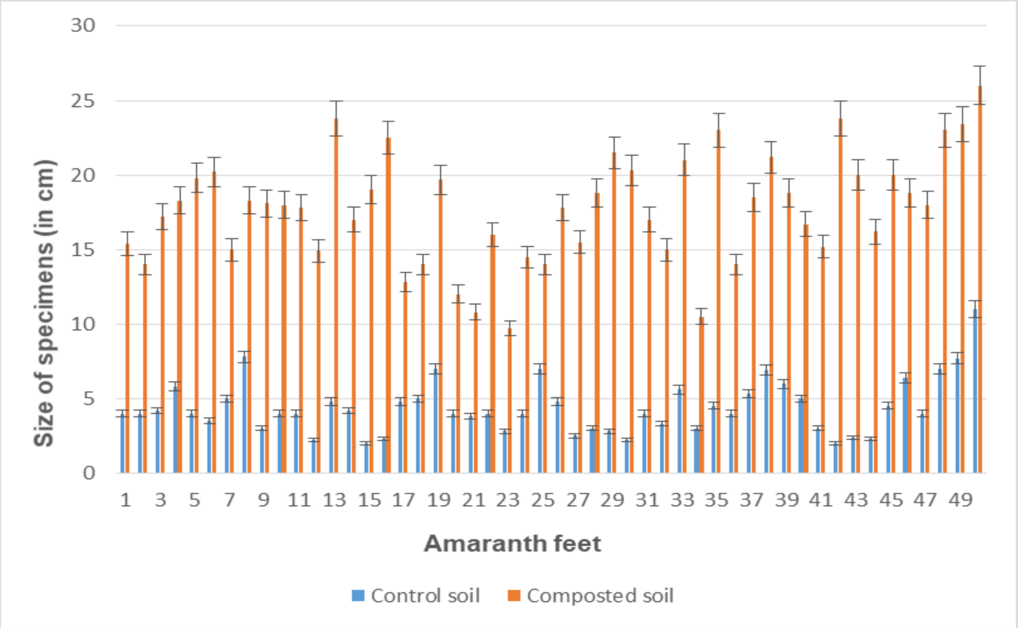

Fig. 12. Measurements of 50-foot stems of Amaranths in control and composted soil after 21 days of growth.

Figure 3 above highlights the influence of compost on crop growth in an agricultural system. The average size of amaranth stems grown on composted soil (17.74 ± 5.23 cm) is significantly greater than that obtained on non-composted soil (4.41 ± 3.19 cm). This difference testifies to the effectiveness of compost in improving the germination power of plants in agriculture.

1.1.3. Data processing and statistical interpretation

Verification of the homogeneity between the 2 variances by finding the value of F calculated:

Here, we take the numerator the largest value the variance and the denominator the smallest value.

So : S2=5,23 >S1=3,19 hence : $F = \frac{S2^2}{S1^2} = \frac{5,23}{3,19} = \mathbf{1,64}$ (Pvalue)

The dof of control soil (S1) and composted soil (S2) = N-1 = 50-1 **=49**

At the threshold of:

- 0.05 degree of confidence = 1.63 (value read in the table = F tabular);

- 0.01 degree of confidence = 2.01 (value read in the table = F tabular).

the comparison between the calculated F (P value) and the Ftabular (from dof).

- If P value < 0.05% degree of confidence: the difference is significant;

- If P value < 0.01% degree of confidence: the difference is very significant;

- If P value > 0.05% degree of confidence: the difference is not significant.

So :

- $F_{calculated}$ (P_{value}) = 1,64 > $F_{tabular}$ = 1,63 to 0,05 : so the difference is no Significant at 0.05% ;
- $F_{calculated}$ (P_{value}) = 1,64 < $F_{tabular}$ = 2,01 to 0,01 : so the difference is very significant at 0.01%.

1.2. Discussion

In view of the results found, it is noted that the large proportion of sellers on the Mfidi market sell biodegradable products (i.e. 76%). On the other hand, those who sell non-biodegradable products represent only 24%. With regard to the method of solid waste management, all in all, the mentality of the population in terms of culture also remains a problem to be solved, because if 78% of the sellers of the Mfidi market throw their waste in the street, 14% are those who throw their waste into the gutters, and 4% throw theirs into a river and the same figure for those who incinerate (4%). This justifies the problems of insalubrity in the city of Kinshasa in general and in the Mfidi market in particular.

This demonstrates that the waste of resources made by sellers in this market remains a problem linked to the culture of the population, because today, waste is a positive utility and therefore raw materials in the face of multiple recovery channels [1] and which have been demonstrated through this work.

This is why [8] thinks that it is necessary for the Congolese State to grasp the reality in terms of waste management in terms of cultural data first before investing in appropriate technologies; because considered as an environment of cultural heterogeneity and intercultural and social segregation.

This classification traces to some extent, the reality of waste as produced in the city of Kinshasa and observed by [9] and [10] although the proportions are slightly different. Indeed, here it was considered a composition in terms of Kilogram of waste and not volume (80%) for Biodegradables, 12% for plastics, 4% for metals, textiles and glasses have 2% each .

For the State service responsible for the evacuation and management of waste at the Mfidi market, 93.3% of sellers recognize its existence and indicate 52% that this service evacuates once a week and 24% that this service evacuates 2 to 3 times a week, solid waste produced in this market. Despite this, it is noted that the disposal of waste in this market is not well ensured despite the payment of the sanitation tax confirmed by 75% of the sellers.

This is why waste management is a problem in the city of Kinshasa. Because those who collect the sanitation tax do not assume their responsibility, despite the education of the population, both young and adult, which is one of the most effective means of a rational waste management policy [11]. responsibility for waste mismanagement in Kinshasa is mainly due to the resignation of the Congolese State, which does not grant the necessary resources to the services responsible for waste management [12], the national sanitation program (PNA) at the time and currently at the Kinshasa sanitation authority (RASKIN).

It requires the support and subsidies of the State because it is foreseeable that the cost of waste disposal will always be heavy to be borne by the population, despite the good will of the participatory management of this population [13]. Due to the lack of a real waste disposal service, the situation is more complicated with urban waste. Their quantities are enormous and their natures complex. Households suffer cruelly from this [14].

The compost obtained is in the range of neutrality (pH 6.7) which corresponds to the acceptable value in international compost standards ranging from 6.5-8.0 [15,16]. The conductivity was 277 µS/cm, respecting the international standard set at a value lower than 1500 µs/cm with a temperature of 26.9°C < 1500 [13,16].

This compost has a dry weight content of 47.3%; which is in agreement with the work of [13] who found 49%. This result complies with [17] which limits a value of >30%.

The total carbon content obtained is 37.2% C; which complies with [17] which gives a value greater than 10%.

The total nitrogen obtained is 2.02%, this result complies with the standards of AFNOR, 2005, which limits a value < to 3%.

The C/N ratio obtained is 18.4; which corresponds to the [18] which limits a value of 15 to 20.

For trace elements (Mn, Fe), Mn has the highest content, i.e. 34.9 mg/kg PS, while iron has a content of 11.0 mg/kg PS. The standard values are respectively 42.33 and 64 [15] for Mn, 15.20 [13] and [14] for Fe.

In the light of the values as recorded in table number 2, the values for each element and heavy metals comply with the standards according to [17] and [18].

Soil plots amended with compost showed a truly significant difference (Pvalue (Fcalculated) = 1.63 < Ftabular = 2.01) at 0.01% confidence level for stem growth between amaranths planted opposite to the control soil plots. And so the compost produced with the waste collected at the Mfidi market played a big role in the fertility of the soil for the cultivation of the amaranths that we used as a test.

So : S2=5,23 >S1=3,19 hence : $F = \frac{S2^2}{S1^2} = \frac{5,23}{3,19} = \mathbf{1,64}\ (\text{Pvalue})$

The dof of control soil (S1) and composted soil (S2) = N-1 = 50-1 **=49**

- $F_{calculated}$ (P_{value}) = 1,64 > $F_{tabular}$ = 1,63 à 0,05 : so the difference is no significant at 0.05%;
- $F_{calculated}$ (P_{value}) = 1,64 < $F_{tabular}$ = 2,01 à 0,01 : so the difference is very significant at 0.01%.

So this compost played a big role in soil fertility for a soil that was sandy. These results are similar to previous studies conducted by [19].

2. Conclusion

The ever-increasing concentration of populations and activities in urban areas generates huge quantities of various wastes with especially harmful consequences on health, the environment, the environment and the quality of life.

Thus, this study had the general objective of cleaning up the Mfidi market through the management and recovery of solid waste.

The results found led to the following conclusions:

 The Mfidi market produces huge quantities of waste, 80% of which is biodegradable. A loss is noticed there, because the majority (78%) of the vendors of the Mfidi market throw their waste in the street, they are followed by those who throw in the gutters (14%);

- It is possible to organize at the level of the Mfidi market, an integrated management of solid waste, which makes it possible to recover organic waste, plastic waste, textiles and glasses ;

- It is therefore possible to better manage and recover the waste produced at the Mfidi Market, to contribute to the sanitation of this site and also to the circular economy with the recovery of all the waste produced. Organic waste yielded 59% compost after three months ;

- The physico-chemical composition of the compost obtained gives a market value to this compost which meets the standards for its use in soil amendment and fertility.

It is therefore suggested:

- That the administration of the Mfidi market can grant the necessary subsidies to the service of collection and disposal of solid waste, for an integrated management of solid waste in the creation of industries for the recycling of non-biodegradable solid waste ;

- The implementation of radio and television broadcasts on raising public awareness of ecological prudence and waste management which are only the unknown raw material ;

- The establishment of mechanisms for the collection of fees due to the collection of waste.

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