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Species diversity and distribution of ruderal flora on landfills in Maradi city, Niger

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***Abstract*—*Waste management continues to be a critical environmental issue in cities. It impacts on the well being of the population, the environment and the biodiversity. In the city of Maradi, in Niger, more interest is given to the problem in order to understand the whole waste management system. It is in this context that this study is carried out to investigate on the role of ruderal flora on the municipal solid wastes dumpsites and landfill sites in Maradi city. The specific objectives are to determine the floristic diversity and distribution of ruderal flora on the municipal solid waste disposal sites, and to identify potential species that can play an important role in the phytoremediation of these sites. In total, 65 species belonging to 52 genera and 24 families were recorded. These species can be categorised into two groups containing anthropic and nitrophilic species according to the ascending Hierarchical Classification (AHC) at 25% similarity. Characteristic species of the first group G1 are Amaranthus viridis and Cucurbita pepo, and Datura innoxia and Cucumis melo for the second group G2. Other ruderal species, namely Amaranthus spinosus L., Amaranthus viridis L., Celosia trygina L., Datura innoxia Mill., and an introduced woody species, Cuphea hyssopifolia Kunth., found are not included in the Maradi city list of species. Datura innoxia, Amaranthus viridis and Amaranthus spinosus are species known to tolerate different degrees of pollution and their ecology should be further study to better understand how they can be used for phytoremediation on this kind of sites.*

Keywords*—*Landfills, flora, species, diversity, distribution, Maradi.

I. INTRODUCTION

Cities in developing countries are subject, on one hand, to a high demographic expansion and on the other, to a massive and fast rural urban migration (Seidl and Mouchel, 2003). Effects of globalization have led population of several large West African cities to an increase in their consumption resulting to an exorbitant increase of household waste (Oxfam-Québec, 2007). Waste production, particularly the solid ones, in urban areas is growing at an unprecedented rate and takes large proportions in those developing countries where their disposal has become an issue of growing concern and paramount (Redjal, 2015).

However, the garbage accumulation and local population exposure create discomforts and affect the population health (Maiti *et al*., 2004; Ouedraogo, 2010).

Consequently, there is a proliferation of disease transmitters and deterioration of the urban environment quality (Tchaou, 2011). Furthermore, dumpsites are characterized by the daily presence of household waste.

The wastes, in many cases, contain matters from animal, vegetal (food rest, organic debris ...) and mineral sources. Thus, they contribute highly to the soil enrichment of these sites especially in organic matter and nutrients.

Also, these sites offer very specific ecological conditions on one hand by the accumulation of organic matter and, secondly, by the existence of a certain contamination by heavy metals. Indeed, several heavy metals buried during waste storage have been identified in urban landfills and dumps, namely, Aluminium (Al), Lead (Pb), Cadmium Cd), Zinc (Zn), Copper (Cu), Iron (Fe), Arsenic (As), etc. (Jourdan *et al.*, 2005; Kimani, 2007; Beyene and Banerjee, 2011; Tankari *et al.*, 2013; Abdourahamane *et al*., 2015).

The presence of these organic matters, inorganic and metal pollutants often alters biodiversity in the area. It leads to the modification of ecological factors that often results in dynamics of plant association and floristic composition of the environment (Falcon, 2012). Also, the transfer of metals, particularly lead, zinc and copper, to aquifers or to plants can lead to harmful effects on people through the food chain because of their toxicity (Fifi, 2009; Jourdan *et al*., 2005; Tankari, 2011). It is well known that hyper-accumulating and accumulating ruderal plants accumulate metals, whatever the concentration rate in soil (Leteinturier & Malaisse, 1999). For example, according to Prasad (2001), *Amaranthus spinosus* and *Amaranthus spinosus* accumulate cadmium in their root, stem and leaves while Abou-Shanab *et al.* (2007) reported that *Cynodon dactylon* accumulate lead, cooper and zinc in their root and shoot. Hence, this recognized capacity of ruderal species to accumulate heavy metal can be used in contaminated sites phytoremediation which is one of the biological soil remediation technologies (Anoliefo *et al*., 2008).

In the city of Maradi in Niger, sanitation is one of the environmental priorities. Indeed, solid waste management, particularly that of household waste, is considered by the city officials as the main sanitation challenge in this city. Solid waste generation sources are mainly households, shops (markets) and industries. Waste disposal techniques and dumpsite management is insufficient in order to avoid contamination of soil, water, biodiversity and humans in this city. Abdourahamane *et al* (2015) even found that in the city of Maradi, the storage of solid waste on the different dumpsites and landfills types is not efficient against the heavy metal contamination such as zinc, cadmium and lead. The limited financial and technical resources also contribute to the mismanagement of the sites. It is in this context that the present study was carried out to investigate the role of ruderal flora on the municipal solid wastes dumpsites and landfill sites in Maradi city. The specific objectives of this work are to determine the floristic diversity and distribution of ruderal flora on the municipal solid waste disposal sites, and to identify potential species that can play an important role in the phytoremediation of these sites.

II. MATERIALS AND METHODS

2.1. Study area

The study was carried out in Maradi city which is the main economic centre of Niger. This city is located between latitudes 13° 32' N to 13° 26' N and longitudes 7° 40' E to 7° 13’ E, and covers 8269 hectares (Fig. 1). The climate is of sahelo-sudanian type with an average temperature varying from 23.21°C in cold period to 40°C in hot period, an average relative humidity of 40.10% (Direction Nationale de la Météorologie, 2013). The mean annual rainfall, calculated over the past thirty years is around 476.89 mm. The hydrographical network is dominated the valley of Goulbi Maradi and some semi-permanent water points. This city is located on a plateau with an average altitude of around 400 m. The soils of Maradi region are tropical ferruginous, rich in silt in the Goulbi zone.

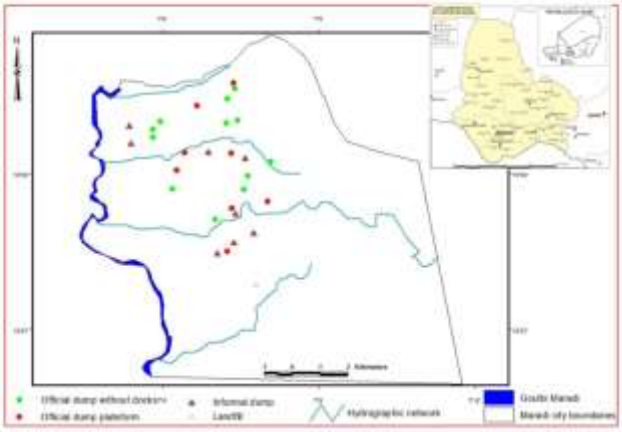

Fig.1: Study area and the sampling sites location

Maradi City has a population of 264,897 inhabitants with an annual growth rate of 4.3% in 2012 (INS, 2013). The availability of water, during a large part of the year allow the development of rainy and irrigated agriculture which is practiced by about 40% of the population of this city.

Waste management in Maradi city is provided by municipal services. The waste disposal is done in three steps (Abdourahamane *et al*., 2015). Firstly, the waste is temporarily stored in containers on the production sites which include homes, markets, main streets, hospitals, etc. Secondly, they are transferred by local people to the dumpsites where they are finally collected by municipal services to be stored in the landfill sites and very rarely buried. Recycling is hardly practiced. However, there are a few collectors of objects from landfills and dumpsites in order to transform into useful domestic tools or sell them to other interested users

2.2. Sites description

The sampling sites are dumps and landfills (Fig. 2).

- Dumpsites: They are of two types: official and informal dumpsite or uncontrolled.

Official dumps are places equipped with dumpsters or garbage containers for waste collection (Concept, 2007). These dumpsters have a capacity of 5.5 m^3 and more or less regularly removed and disposed of in landfills or other sites. There are two categories of official dumpsites in Maradi city: (i) the "dumps platforms" that are equipped with a three-compartment system with a dock for easy access to the dumpster, a terrace of about 5 m^3 in the downstream portion in contact with two or three containers with a small hut for on-site caretaker, and (ii) the "official dumps without docks", the most abundant in the city, which are simply characterized by the presence of a dumpster or other container. They are officially recognized by the municipality. Informal or uncontrolled dumps, unlike officials, are waste consolidation sites without official municipality permission, created by neighbouring inhabitants because of the lack of formal

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dumpster or the relatively long distance to an official dumpsite, making it inaccessible (Concept, 2007). They are usually located in inappropriate places, in the streets, often alongside health or education infrastructure, etc.

- Landfills: Last link in the waste disposal chain, these are quarries or areas adjacent to the city where the collected waste from dumpsites are eliminated. They are often very large uncontrolled dumpsites.

Fig.2: Different waste disposal sites
(adopted from Abdourahamane *et al*., 2015)

2.3. Sampling and Data collection on the herbaceous flora

Herbaceous plants sampling was carried out on six official dumpsites, six informal dumpsites and four landfill sites. Data collection was done in a 100 m2 sampling plots (10m x10m) on every site. Surveys were conducted along transects considering the main roads that run alongside these sites as main line. Transects were established perpendicular to this line towards landfills. The equidistance between adjacent transects is 15 m and 10 m between neighbouring plots on the same transect. Given the area covered by vegetation on dumps and landfills sites, plots were established to cover areas with vegetation as representative of the study site, as well as possible. Thus, on each plot, 2 transect lines were used for data collection. A total of 30 records were made on dumpsites and landfill sites.

Phytosociological records were made using the Braun-Blanquet sigmatiste method (1932). This method has the advantage to draw up an exhaustive list of all the plant species present in the plot. These records were completed by the Daget and Poissonet linear method (1971). Two lines of quadrats points were performed in each plot. Each line has 20 m of length and includes 100 points of contact.

2.4. Data analysis

Phytosociological records of the herbaceous layer collected were formed into a matrix of plant species abundance-dominance. This expresses the number of individuals of the same species and their degree of recovery. This matrix has been subjected to an Ascending Hierarchical Classification (AHC) using PC ORD software version 5. The resulted information table is summarized in a dendrogram. Analysis allows discriminating plant communities on the basis of similarity at the Sorensen index level (Legendre and Legendre 1998). Shannon and Weaver diversity (1949) and Pielou equitability (1966) indexes were calculated in order to analyze vegetation diversity of dumpsites and landfill sites.

III. RESULTS AND DISCUSSION

In this environmental context, floristic richness analysis of dumpsites and landfill sites of Maradi city revealed a relatively high floristic diversity despite the hash living conditions for many species. On the study area, 65 species belonging to 52 genera and 24 families were recorded (Table 1). Fabaceae and convolvulaceae were the most represented families with 6 species each, followed by Cucurbitaceae and Poaceae with 5 species each, the Malvaceae with 4 species. The families of Amaranthaceae, Acanthaceae, Cyperaceae, Solanaceae, Pedaliaceae and Rubiaceae are represented by 3 species each. Caesalpiniaceae, Aizoaceae, Commelinaceae, Euphorbiaceae and Tiliaceae families have 2 species each. Other families are Asclepiadaceae, Asteraceae, Capparidaceae, Lamiaceae, Molluginaceae, Nyctaginaceae and Zygophyllacea represented by one single species.

Table.1: Floristic list of dumpsites and landfill sites of Maradi city

Species	Families
Acanthospermum hispidum DC.	Asteraceae
Alysicarpus ovalifolius (Schum. Et Thonn.) J. Léonard.	Fabaceae
Amaranthus spinosus L.	Amaranthaceae
Amaranthus viridis L.	Amaranthaceae
Boerhavia erecta L.	Nyctaginaceae
Borreria scabra (schum.EtThonn.) K.Schum	Rubiaceae
Borreria stachydea (DC) hutch. Et Dalz	Rubiaceae
Cassia mimosoides L.	Caesalpiniaceae
Cassia occidentalis L.	Caesalpiniaceae
Celosia trygina L.	Amaranthaceae
Cenchrus biflorus Roxb.	Poaceae
Ceratotheca sesamoides Endl.	Pedaliaceae
Citrullus colocynthis (L.) Schard.	Cucurbitaceae
Citrullus lanatus (thunb.)Matsumara et makai	Cucurbitaceae
Cleome viscosa L.	Capparidaceae
Commelina benghalensis L.	Commelinaceae

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Commelina forskalaei Vahl.	Commelinaceae
Corchorus tridens L.	Tiliaceae
Cucurbita pepo L.	Cucurbitaceae
Cyperus esculentus L.	Cyperaceae
Cyperus rotundus L.	Cyperaceae
Dactyloctenium aegyptium (L.) Willd.	Poaceae
Datura innoxia Mill.	Solanaceae
Digitaria horizontalis Wild.	Poaceae
Echinochloa colona (L.) Link	Poaceae
Eleusine indica (L.) Gaertn	Gramineae
Eragrostis tremula Steud.	Poaceae
Euphorbia hirta L.	Euphorbiaceae
Evolvulus alsinoides (L.) L.	Convovulaceae
Gisekia pharnacioides L.	Aizoaceae
Hibiscus asper Hook. f.	Malvaceae
Hibiscus sabdariffa L.	Malvaceae
Indigofera astragalina DC.	Fabaceae
Indigofera pulchera Willd.	Papilonaceae
Ipomoea coptica (L.) Roth. ex. Roem. et Schult.	Convolvulaceae
Ipomoea dichroa Hachst.Ex Choisy	Convolvulaceae
Ipomoea vagans Bak.	Convolvulaceae
Jacquemontia tamnifolia (L.) Griseb.	Convolvulaceae
Kyllinga squamulata Thonn.Exvahl.	Cyperaceae
Leucas martinicensis (Jacq.) R. Br.	Lamiaceae
Merremia tridentata (L.) Hallier. f.	Convolvulaceae
Mitracarpus scaber (Sw.) DC.	Rubiaceae
Mollugo nudicaulis Lam.	Molluginaceae
Momordica balsamina L.	Cucurbitaceae
Monechma ciliatum (Jacq.) Milne. Red.	Acanthaceae
Mukia maderaspatana (L.) Roem.	Cucurbitaceae
Pennisetum pedicellatum Trin.	Graminea
Pergularia tomentosa L.	Asclepiadaceae
Peristrophe bicalyculata (Retz)Nees .	Acanthaceae
Peristrophe paniculata (Forssk.) Brum mitt	Acanthaceae
Phyllanthus pentandrus Schum. et Thonn.	Euphorbiaceae
Physalis angulata L.	Solanaceae
Physalis lagascae Roem. Et Schult.	Solanaceae
Ricinus communis L.	Euporbiacea
Rogeria adenophylla J. Gay.	Pedaliaceae
Sesamum alatum Thon.	Pedaliaceae
Sesbania pachycarpa DC.	Fabaceae
Sida alba L.	Malvaceae
Sida cordifolia L.	Malvaceae
Solanum lycopersicum L.	solanaceae
Tribulus terrestris Viv.	Zygophyllaceae
Trienthema portulacastrum (L.) L.	Aizoaceae
Triumfetta pentandra A. Rich.	Tiliaceae
Vigna unguiculata (L.) Walp. Subsp. Unguiculata	Fabaceae
Zornia glochidiata Reichb. Ex DC.	Fabaceae

The dendrogram derived from Ascending Hierarchical Classification (AHC) has allowed individualizing the different plant groups. Analysis divided the records into two groups (Fig. 3) at the level of 25%: *Amaranthus viridis* and *Cucurbita pepo* group (G1) and *Datura innoxia* and *Cucumis melo* group (G2).

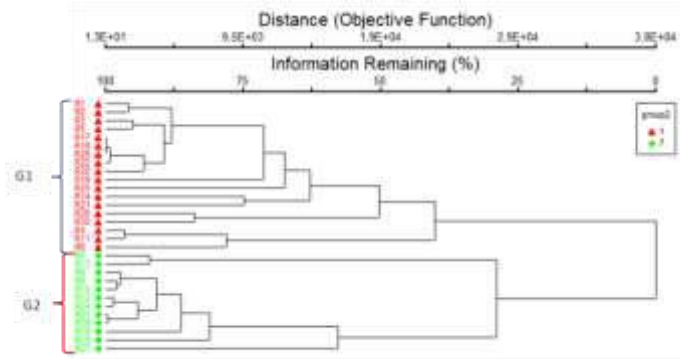

Fig.3: Dendrogram of plant group of species found on the different dumpsites and landfills in Maradi city

The group 1 of *Amaranthus viridis* and *Cucurbita pepo* is composed of 44 species (18 records) (Table 2). *Amaranthus viridis*, *Cucurbita pepo*, *Amaranthus spinosus*, *Corchorus tridens* are the characteristic species of this group. The companion species are *Sida cordifolia*, *Trianthema portulacastrum* and *Cleome gynandra*. This group belongs to the class of *Ruderali mahihotetea* Taton 1949, class containing anthropic and nitrophilic groups, trampled, from rubble and roadsides. The Shannon-Weaver index, of 4.46 bits, reveals a high diversity within this group. The equitability index, of 0.94 bits, indicates that several species participate in the recovery.

Table 2: Floristic list of the Group 1

Species	**Families**
Acanthospermum hispidum DC.	Asteraceae
Alysicarpus ovalifolius (Schum. Et Thonn.) J. Léonard.	Fabaceae
Amaranthus spinosus L.	Amaranthaceae
Amaranthus viridis L.	Amaranthaceae
Boerhavia erecta L.	Nyctaginaceae
Borreria scabra(schum.EtThonn.)K.Schum	Rubiaceae
Borreria stachydea (DC) hutch. Et Dalz	Rubiaceae

Cassia mimosoides L.	Caesalpiniaceae
Cassia occidentalis L.	Caesalpiniaceae
Celosia trygina L.	Amaranthaceae
Cenchrus biflorus Roxb.	Poaceae
Citrullus lanatus (thunb.)Matsumara et makai	Cucurbitaceae
Cleome viscosa L.	Capparaceae
Commelina benghalensis L.	Commelinaceae
Commelina forskalaei Vahl.	Commelinaceae
Corchorus tridens L.	Tiliaceae
Cucurbita pepo L.	Cucurbitaceae
Cyperus esculentus L.	Cyperaceae
Dactyloctenium aegyptium (L.) Willd.	Poaceae
Datura innoxia Mill.	Solanaceae
Digitaria horizontalis Wild.	Poaceae
Eragrostis tremula Steud.	Poaceae
Euphorbia hirta L.	Euphorbiaceae
Hibiscus sabdariffa L.	Malvaceae
Indigofera pulchra Willd.	Fabaceae
Ipomoea coptica (L.) Roth. ex. Roem. et Schult.	Convolvulaceae
Ipomoea dichroa Hachst.Ex Choisy	Convolvulaceae
Ipomoea vagans Bak.	Convolvulaceae
Kyllinga squamulata Thonn.Exvahl.	Cyperaceae
Leucas martinicensis (Jacq.) R. Br.	Lamiaceae
Mitracarpus scaber (Sw.) DC.	Rubiaceae
Monechma ciliatum (Jacq.) Milne. Red.	Acanthaceae
Pennisetum pedicellatum Trin.	Poaceae
Pergularia tomentosa L.	Asclepiadaceae
Peristrophe bicalyculata (Retz)Nees .	Acanthaceae
Ricinus communis L.	Euphorbiaceae
Rogeria adenophylla J. Gay.	Asclepiadaceae
Sesamum alatum Thon.	Pedaliaceae
Sesbania pachycarpa DC.	Fabaceae
Sida cordifolia L.	Malvaceae
Solanum lycopersicum L.	Solanaceae
Tribulus terrestris Viv.	Zygophyllaceae
Trienthema portulacastrum (L.) L.	Molluginaceae
Zornia glochidiata Reichb. Ex DC.	Fabaceae

The group 2 of *Datura innoxia* and *Cucumis melo* is composed of 40 species (12 records) (Table 3). The characteristic species of this group are *Datura innoxia*, *Cucumis melo*, *Physalis lagascae*, *Sida cordifolia*, *Ricinus communis*. The companion species are *Amaranthus viridis*, *Corchorus tridens*, *Cyperus rotondus*, *Cleome gynandra*. Like the previous one, this group belongs to the syntaxon of the *Ruderali manihotetea* Taton 1949. The value of the Shannon-Weaver index, of 3.39 bits, shows that the diversity within this group is moderate. The equitability index, of 0.96 bits, shows that a several species participate in the recovery.

Table 3: Floristic list of the Group 2

Species	Families
Acanthospermum hispidum DC.	Asteraceae
Alysicarpus ovalifolius (Schum. Et Thonn.) J. Léonard.	Fabaceae
Amaranthus spinosus L.	Amaranthaceae
Amaranthus viridis L.	Amaranthaceae
Boerhavia erecta L.	Nyctaginaceae
Borreria stachydea (DC) hutch. Et Dalz	Rubiaceae
Cassia occidentalis L.	Caesalpiniaceae
Celosia trygina L.	Amaranthaceae
Cenchrus biflorus Roxb.	Poaceae
Citrullus lanatus (thunb.)Matsumara et makai	Cucurbitaceae
Cleome viscosa L.	Cappparaceae
Cleome gynandra L.	Capparaceae
Commelina benghalensis L.	Commelinaceae
Commelina forskalaei Vahl.	Commelinaceae
Corchorus tridens L.	Tiliaceae
Cucumis melo L.	Cucurbitaceae
Cucurbita pepo L.	Cucurbitaceae
Cyperus esculentus L.	Cyperaceae
Dactyloctenium aegyptium (L.) Willd.	Poaceae
Datura innoxia Mill.	Solanaceae
Digitaria horizontalis Wild.	Poaceae
Eragrostis tremula Steud.	Euphorbiaceae
Euphorbia hirta L.	Euphorbiaceae
Indigofera pulchra Willd.	Fabaceae
Ipomoea vagans Bak.	Convolvulaceae
Ocimum gratissimum L.	Lamiaceae
Mariscus squarrosus (L.) C.B. Cl.	Cyperaceae
Pennisetum typhoides Stapf.	Poaceae
Pennisetum pedicellatum Trin.	Poaceae
Peristrophe bicalyculata (Retz)Nees .	Acanthaceae
Physalis lagascae Roem. Et Schult.	Solanaceae
Ricinus communis L.	Euphorbiaceae
Rogeria adenophylla J. Gay.	Pedaliaceae
Sesamum alatum Thon.	Pedaliaceae
Sesbania pachycarpa DC.	Fabaceae
Sida cordifolia L.	Malvaceae
Solanum lycopersicum L.	Solanaceae
Tribulus terrestris Viv.	Zygophyllaceae

Trienthema portulacastrum (L.) L.	Aizoaceae
Triumfetta pentandra A. Rich.	Tiliaceae

The Sorensen index of similarity between the two groups is of 42.98%, thus showing that they are each other independents. The analysis shows a relatively high floristic richness depending on the considered group. Thus, comparison between groups showed a high diversity within G1 than in G2. Comparison between the floristic lists of dumps and landfills sites with those of Maradi Tannery (Mahamane, 2012) and Maradi (Saadou, 1990) was done using the similarity Sorensen index (Table 4). Analysis of the results shows very low similarities between the three floristic lists. The highest rate is obtained between the floristic lists of dumps and landfills sites and Maradi Tannery.

Table 4: Similarity matrix between the floristic lists(in %)

Floristic lists	Dumps and landfills sites	Maradi Tannery	Maradi list
Dumps and landfills sites	-		
Maradi Tannery	31,25	-	
Maradi list	20,74	17	-

Some of herbaceous species found on the dumps and landfills sites are not included in the Maradi floristic list. These are ruderal species, namely *Amaranthus spinosus* L., *Amaranthus viridis* L., *Celosia trygina* L. and *Datura innoxia* Mill., and an introduced woody species, *Cuphea hyssopifolia* Kunth..

The very low similarities found between the floristic list of dumps and landfills sites with those of Maradi Tannery (from 2012) and Maradi (from 1990) is due to the urbanization effect. Therefore to ecological conditions change that occurs in the city over the years and the existence of particular conditions at dumps and landfills sites. The specific ecological conditions of these sites are characterized, firstly, by an overabundance of organic matter and a sun exposure throughout the year and, secondly, by the existence of some heavy metals contamination (Abdourahamane *et al.*, 2015). In fact, ruderal species are the best represented in the two groups.

Also, the toxicity of heavy metals operates a very thorough selection, eliminating many species that are found in these places. Indeed, the very severe selective screening imposed by metal toxicity can cause rapid evolution towards high tolerance levels. Although the flora of dumps and landfills habitats comes from ordinary habitats, species that compose it gather in particular vegetation compared to local ordinary habitats (Ernst, 1974 in Falcon (2012)). Plant colonization of these habitats is partly driven by the populations of existing non-tolerant plants nearby. The pH of these sites plays an important role in this selection. It act, on one hand, directly on the level of nutrients availability in the substrate, but also, one the other hand, on soil microbial activity causing organic matter decomposition and its mineralization. A pH between 6.5 and 8 is favorable for the installation of ground vegetation cover of herbaceous types (Henry *et al.*, 2011). Characteristically, the growth of woody species (trees and shrubs) is inhibited, leading to the development of plant groups purely herbaceous or slightly shrub (Falcon, 2012). This would explain the predominance of ruderal species in the floristic composition of the dumps and landfills sites vegetation. In addition, some species, like *Datura innoxia*, *Amaranthus viridis* and *Amaranthus spinosus* of the ruderal flora, found exclusively in these sites, have the ability to tolerate heavy metals presence and accumulation at variable rates including those found by Abdourahamane *et al.* (2015) in the study area (Kouamé *et al.*, 2006; Jean, 2007; Dazy, 2008; Atayese, 2009; Messou *et al*., 2013; Messou *et al*., 2015). In fact, several studies have showed that *D. innoxia* tolerates many heavy metals accumulation: Jean (2007) for zinc, nickel and chrome; Salt *et al.* (1995) for cadmium and Vaillant *et al*. (2005) for zinc. While many others have shown that the heavy metals tolerance and phytoaccumulation capacity of *A. viridis* and *A. spinosus*: Messou *et al.* (2013) for cadmium, lead, zinc, iron etc.; Prassad (2001) for cadmium, zinc, lead, cooper and iron; Abe *et al.* (2001) for cadmium, etc. These are metallicolous or metallophytes species. They develop special strategies to survive and colonize these environments with contrasting ecological conditions. Indeed, metallicolous species, tolerant to metals, have the ability to survive and reproduce on toxic or adverse soil to most of others organisms because of metal contamination, and metallophytes would be endermic, species associated with soil contrasting chemical conditions.

Finally, the study of the ecology of species counted on landfills and dumps sites in Maradi city reveals the preponderance of ruderal species. That illustrates the impact of landfills and dumpsites on the herbaceous vegetation which tends towards a homogenization in ruderal flora.

IV. CONCLUSION

The preponderance of those exclusive ruderal species in the floristic composition of the majority of sites illustrates the natural capacity of pollutant removal. Waste management through phyto-remedation is an alternative that should be further investigated by the municipal sanitation services. *Datura innoxia*, *Amaranthus viridis* and *Amaranthus spinosus*. species are suitable candidates in phytoremediation project and an ecological waste management system in this city of Maradi.

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