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Short Note

Municipal Solid Waste and the Plant Diversity on Landfill Site of Doon Valley

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Abstract: Solid waste generation and its disposal to safer sites are posing a threat to environment and human existence. Due to poor solid waste management practices, problems of health, sanitation and environmental degradation are unavoidable. In the current paper we have tried to assess the total Municipal Solid Waste (MSW) generated in Doon Valley and its disposal to landfill site along with the plant species that grow on this site. A total of 116 plant species were recorded growing in landfill site. They included two tree species, four shrub species and remaining herb species. These included many invasive species like *Lantana camara, Eupatorium adenophorum, Ageratum conyzoides* and *Parthenium hysterophorus*. The plants are best source to remediate the solid wastes and this technique is phytoremediation. However, it is a slow process but certainly cost effective.

Key words: Phytoremediation, solid waste, Nagar Nigam, landfill, MSW.

Introduction

The term "solid waste" usually refers to waste that is solid, including semi liquid or wet wastes with insufficient moisture or fluid content to be free flowing (CPCB, 2000). "Municipal solid waste" (MSW) is a heterogeneous mixture of various constituents.

The uncontrolled decomposition of organic constituents of waste results in various environmental problems (NEERI, 1995). The problem of municipal solid waste is as old as civilization itself. With rapid urbanization and industrial revolution, the problem began to grow more serious. The problems grow more complicated with arrival of non-biodegradable plastic containers, polythene wrappers etc. The disposal of garbage is one of the most irritating problems for urban communities.

Improper solid waste management gives rise to problems of health, sanitation and environmental degradation. WHO studies have indicated that 22 diseases are directly linked to improper solid waste management practices. Rodents and vector insects transmit various diseases like dysentery, cholera, plague, typhoid, infective hepatitis and others. Special epidemiological studies have also shown that workers engaged in solid waste management services are exposed to high health risk and frequently suffer from respiratory tract infection, gastro-intestinal parasites and worms (Travis & Hattemer-Frey, 1991). The organic components of solid waste provide food and shelter to disease carrying rodents and insects. Improper management of waste can therefore spread several diseases. A number of foreign agencies and workers have worked for MSW management (Johnson, 1982; O'Leary et al., 1988; Gochfeld, 1995; World Bank, 1997a, b, 1999). In India, MSW disposal and rules related to it are primarily worked out by government agencies (NEERI, 1995; SC, 1999; CPCB, 2000; GOI, 2003 and MOUD Report, 2005). However, some isolated works are carried out by individual workers (Aggarwal, 2001; Aurobindo, 2002; Akolkar, 2005).

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The contaminants of landfill can negatively influence the plants. However, plants can also be used for removal of selected pollutants. In other countries, studies on floral diversity of landfill sites along with methane emission have been carried out by a number of workers (Whalen et al., 1990; Moffat & Houstan, 1991; Gendebien et al., 1992; Maurice et al., 1995; Zacharias, 1995; Maurice, 1998). However, in India, only a few workers have undertaken such studies (Kumar et al., 2004; Kumar & Gaikwad, 2004). Sicilano and Germid (1998) and Schwitzguebel et al. (2002) have reported phytoremediation of MSW landfills. Plants growing in MSW landfills serve for the removal of different pollutants.

The present paper investigates the floral diversity of Doon Valley MSW Landfill site, so that selection of certain species can be done for rehabilitation of the dump site.

Study Site

Municipal Landfill site of Dehradun is located on the Sahastradhara Road. The landfill site covers the 4.5 acre area. Landfill site is approximately flat with gentle slope of North to South direction. This site is used for dumping the Municipal Waste for the last eight years.

The disposal site was selected on the basis of their closeness to the collection areas rather than their technical and environmental suitability. These unplanned heaps of uncovered wastes, often burning and surrounded by pools of stagnated polluted water, rat and fly infestations with domestic animals roaming freely and families of scavengers picking through the wastes is not only an eyesore but a great environmental hazard in Doon Valley. Landfill method used in the present study area do not confirm to the specifications of CPCB (2000).

Methodology

MSW Landfill site was surveyed exhaustively throughout the study period. Each visit to the site concentrated on the plant species growing during different seasons. The collected specimens were processed, preserved and mounted on herbarium sheets. The field data on habit, habitat, flower colour, etc. was recorded in a field notebook.

Specimens were identified from BSD, DD Herbaria, both at Dehradun. Identified plants are deposited in DDN (Herbarium of Botany Department, D.A.V. (P.G.) College, Dehradun).

Observations and Results

General composition of MSW of D.Dun is similar to MSW of class I and II cities. It has maximum contribution (<40% by weight) from vegetable leaves and stones (Figure 1). It also includes categories like paper, plastic, glass, ceramics, metal and other miscellaneous categories.

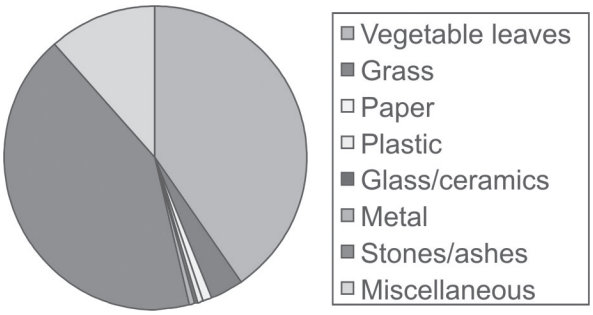

Figure 1: General composition of MSW of Dehradun.

A total of 116 plants species belonging to 45 families were recorded (Table 1). Dicots contributed maximum (82%) at species level (Table 2). Herbs dominated the site over other growth forms. Poaceae, Cucurbitaceae, Asterceae and Solanaceae emerged as dominant families of the site. Castor (*Ricinus communis*), an oil yielding plant, grew well and formed bushy patches at many locations of the landfill. Seedlings and saplings of *Mangifera indica, Bombax ceiba, Dalbergia sissoo*, *Melia azaderach* and *Aegle Marmelos* were also recorded with stunted growth.

A maximum 65% of the total biodiversity was recorded in herbaceous form (Table 3). Climbers/Twiners and seedlings and saplings of trees were represented by 11 species and 13 species respectively. Only 10 shrubs species were recorded during the entire study. Thirty species recorded from the landfill site fall under cultivated plants category with 26 species as dicots and only four species as monocots (Table 4). Wild plants species identified from the site included 68 dicots and 18 monocots. Thus, the diversity of landfill flora has 79% wild dicots and 77% cultivated dicots.

Table 1: Species diversity at MSW landfill site

S.N.	Family	Genera	Species	Growth habit*
1.	Acanthaceae	*Adhatoda*	*Adhatoda vasica* Nees	W
2.	Amaranthaceae	*Amaranthus*	*Amaranthus tricolor* L.	C
3.			*Amaranthus spinosus* L.	W
4.		*Achyranthes*	*Achyranthes aspera* L.	W
5.		Alternanthera	*Alternanthera sessilis* (L.) DC.	W
6.		Celosia	*Celosia argentea* L.	W
7.	Anacardiaceae	Mangifera	*Mangifera indica* L.	C
8.	Annonaceae	Uvaria	*Uvaria velutina* Dunal	W
9.	Apocynaceae	*Catharanthus*	*Catharanthus roseus* (L.) G.Don	C
10.	Asclepidaceae	*Calotropis*	*Calotropis procera* (Aiton) Dryander	W
11.	Asteraceae	*Ageratum*	*Ageratum conyzoides* L.	W
12.		*Bidens*	*Bidens pilosa* L.	W
13.		*Galinsoga*	*Galinsoga parviflora* Cav.	W
14.		*Hyptis*	*Hyptis suaveolens* L.	W
15.		*Tridax*	*Tridax procumbens* L.	W
16.		Vernonia	*Vernonia cinerea* (L.) Lessing	W
17.		*Xanthium*	*Xanthium strumarium* L.	W
18.	Bignoniaceae	*Milingtonia*	*Milingtonia hortensis* L.f.	W
19.	Bombacaceae	*Bombex ceba*	*Bombex ceiba* L.	W
20.	Boranginaceae	*Heliotropium*	*Heliotropium strigosum* Willd.	W
21.	Brassicaceae	*Brassica*	*Brassica campestris* L.	C
22.	Cactaceae	*Opuntia*	*Opuntia elatior* Miller	W
23.	Chenopodiaceae	*Chenopodium*	*Chenopodium album*	C
24.			*Chenopodium ambrosoides* L.	W
25.	Cannabinaceae	*Canabis*	*Canabis sativa* L.	W
26.	Caesalpinieaceae	*Cassia tora*	*Cassia tora* L.	W
27.		*Delonex*	*Delonex regia* (Bojer ex Hook.f.) Raf.-Sachm.	C
28.		*Tamarindus*	*Tamarindus indica* L.	C
29.	Cleomaceae	*Cleome*	*Cleome viscosa* L.	W
30.	Convolvulaceae	*Argyreia*	*Argyreia thomsonii* (C.B. Clarke) Craib,	W
31.		*Ipomea*	*Ipomea pes-tigridis* L.	W
32.			*Ipomoea carica* (L.) Sweet	W
33.			*Ipomoea fistulosa* Martius ex Choisy	W
34.			*Ipomoea nil* (L.) Roth	W
35.	Cucurbitaceae	*Benincasa*	*Benincasa hispida* (Thunb.) Cogniaux	C
36.		*Citrullus*	*Citrullus colocynthis* (L.) Schrader	C
37.		*Cucumis*	*Cucumis melo* L.	C
38.		*Cucurbita*	*Cucurbita moschata* Duchesne ex Poiret	C
39.		*Lagenaria*	*Lagenaria siceraria* (Molina) Standley	C
40.		*Luffa*	*Luffa acutangula* (L.) Roxb., Hort. Beng.	C
41.			*Luffa Cylindrica* (L.) M. Roemer	C
42.		*Momordica*	*Momordica charantia* L.	C
43.		*Mukia*	*Mukia maderspatana* (L.) M. Roemer	W
44.	Ehretiaceae	*Cordia*	*Cordia dichotoma* Forester f.	W
45.	Euphorbiaceae	*Acalypha*	*Acalypha indica* L.	W
46.		*Baliospermum*	*Baliospermum montanum* (Willd.) Muell.-Arg.	W
47.		*Euphorbia*	*Euphorbia hirta* L.	W
48.			*Euphorbia hypericifolia* L.	W
49.		*Phyllanthus*	*Phyllanthus niruri auct.* Pl.	W
50.		*Ricinus*	*Ricinus communis* L.	W

(Contd.)

(Table 1 *contd.*)

51.	Fabaceae	*Alysicarpus*	*Alysicarpus vaginalis* (L.) DC.	W
52.		*Crotalaria*	*Crotalaria juncea* L.	C
53.		*Dalbergia*	*Dalbergia sissoo* Roxb.	C
54.		*Phaseolus*	*Phaseolus mungo* L.	C
55.		*Atylosia*	*Atylosia volubilis* (Blanco) Gamble	W
56.		*Desmodium*	*Desmodium triflorum* (L.) DC.	W
57.	Lamiaceae	*Mucuna*	*Mucuna pruriens* (L.)dc.	W
58.		*Ocimum*	*Ocimum sanctum* L.	C
59.		Ajuga	*Ajuga bracteosa* Wallich ex Benth.	W
60.		Cloebrookia	*Cloebrookia oppositifolia* J.E. Smith	W
61.		Leucas	*Leucas cephalotes* (Roth) Sprengel	W
62.	Lauraceae	*Litsea*	*Litsea polyantha* Juss.	W
63.	Malvaceae	*Malvastrum*	*Malvastrum coromandelianum* (L.) Garcke	W
64.		*Sida*	*Sida rhombifolia* L.	W
65.	Meliaceae	*Melia*	*Melia azedarach* L.	W
66.	Mimosesa	*Acacia*	*Acacia nilotica* (L.) Delile	W
67.		*Mimosa*	*Mimosa pudica* L.	W
68.	Molluginaceae	*Glinus*	*Glinus lotoides* L.	W
69.	Nyctaginaceae	*Boerhavia*	*Boerhavia erecta* L.	W
70.	Onagraceae	*Psidium*	*Psidium guajava* L.	C
71.	Papaveraceae	*Argemone*	*Argemone Mexicana* L.	W
72.	Pedaliaceae	*Sesamum*	*Sesamum indicum* L.	C
73.	Polygonaceae	*Rumex*	*Rumex detatus* L.	W
74.	Punicaceae	*Punica*	*Punica granatum* L.	C
75.	Rhamnaceae	*Zizyphus*	*Zizyphus jujube* (L.) Gaertner	W
76.	Rubiaceae	*Borreria*	*Borreria articularis* (L.f.) F.N. Williams	W
77.			*Borreria pusilla* (Wallich) DC.	W
78.		*Hedyotis*	*Hedyotis pinifolia* Wallich	W
79.	Rutaceae	*Aegle*	*Aegle marmilosa* (L.) Correa	C
80.		*Citrus*	*Citrus limon* (L.) Burm	C
81.		*Murraya*	*Murraya paniculata* (L.) Jack	W
82.	Scrophulariaceae	*Lindernia*	*Lindernia anagalis* (Burm.f.) Pennell	W
83.	Solanaceae	*Lycopersicon*	*Lycopersicon lycopersicum* (L.) Karaten	C
84.		*Physalis*	*Physalis minima* L.	W
85.			*Physalis peruviana* L.	W
86.		*Solanum*	*Solanum indicum auct.non* L.	W
87.			*Solanum khasianum* Clarke	W
88.			*Solanum nigrum* L.	W
89.			*Solanum xanthocarpum* Schrader & Wendland	W
90.	Tiliaceae	*Corchorus*	*Corchorus capsularis* L.	C
91.	Urticaceae	*Boehmaria*	*Boehmaria platyphylla* D.Don	W
92.	Verbinaceae	*Pouzolzia*	*Pouzolzia pentandra* (Roxb.) Bennett & Brown	W
93.		*Vitex*	*Vitex negundo* L.	W
94.		*Lantana*	*Lantana camara* L.	W
95.	Commelinaceae	Commelina	Commelina maculate Edgew	W
96.	Cyperaceae	*Carex*	*Carex cruciata* Wahlenberg	W
97.		*Cyperus*	*Cyperus iria* L.	W
98.			*Cyperus kyllinga* Endl.	W
99.			*Cyperus niveus* Retz.	W
100.			*Cyperus rotundus* L.	W
101.	Liliaceae	*Fimbristylis*	*Fimbristylis acicularis* R.Br.	W
102.		*Asparagus*	*Asparagus racemosus* Willd	C
103.	Poaceae	*Avena*	*Avena sativa* Bor	C
104.		*Hordeum*	*Hordeum vulgare* L.	C

(*Contd.*)

(*Contd.*)

105.	*Triticum*	*Triticum aestivum* L.	C
106.	*Arundinella*	*Arundinella pumila* (Hochst. Ex Richard) Steudel	W
107.	*Chrysopogon*	*Chrysopogon aciculatus* (Retz.) Trinius.	W
108.		*Chrysopogon fulvus* (Sprengel) Chiovenda	W
109.	*Cynodon*	*Cynodon dactylon* (L.) Persoon	W
110.	*Digitaria*	*Digitaria bicornis* (Lam.) Roemer & Scules ex Loudon	W
111.	*Eleusine*	*Eleusine indica* (L.) Gaertner	W
112.	*Eragrostis*	*Eragrostis unioloides* (Retz.) Nees ex Steudel	W
113.	*Erianthus*	*Erianthus rufipilum* (Steudel) Grisbach	W
114.	*Paspalidium*	*Paspalidium flavidum* (Retz.) A. Camus	W
115.	*Saccharam*	*Saccharam Munja* Roxb.	W
116.	*Setaria*	*Setaria glauca* (L.) P. Beauv.	W

* C is cultivated and W is wild.

Table 2: Angiospermic diversity in various categories of taxa at MSW landfill site of Dehradun

S.No.	*Rank of Taxa*		*Number*	*Percentage (%)*
1	Family	Dicot	41	91.10
		Monocot	04	8.90
2	Genera	Dicot	82	82
		Monocot	18	18
3	Species	Dicot	94	81.03
		Monocot	22	18.97

Table 3: Growth habit of plant diversity at landfill site of MSW in Doon Valley

S.No.	*Habit*	*Number*	*Percentage (%)*
1.	Climber	11	9.48
2.	Herb	76	65.51
3.	Shrub	10	8.62
4.	Trees (Seedlings and Saplings)	13	11.20
5.	Undershrub	06	5.17

Table 4: Variation in composition of cultivated and wild species at MSW landfill site in Doon Valley

Category		*Number*	*Percentage (%)*
Cultivated	M	04	13.33
	D	26	76.66
Wild	M	18	20.93
	D	68	79.06

Discussion

A floral diversity of 116 plant species in an area of 4.5 acres of landfill site indicate species richness. The dominance of wild species (86) over cultivated (30 species) is a good signal for phytoremediation measures. Presence of oil yielding Castor plant in good number opens up avenues for both short listing of species selected for rehabilitation process and to evaluate the ecological requirements of plants.

Presence of seedlings and saplings of many tree species may appear interesting at one glance but the stunted and deformed growth indicates their vulnerability to the prevailing environmental factors. Medicinal plants, like *Adhatoda vasica, Achyranthes aspera, Calotropis procera, Ocimum sanctum, Aegle marmelos*, *Vitex negundo* and *Catharanthus roseus* are observed growing on landfill. They also provide a clue for commerce along with rehabilitation measures. Among the invasive exotic species occurring vigorously in adjoining area only *Lantana camara* and *Ageratum conyzoides* were recorded in moderate numbers. *Parthenium hysterophorus* and *Eupatorium odoratum* were completely absent from the landfill site; however, they are very vigorous in adjoining areas.

In the present study, Poaceae, Cucurbitaceae, Asterceae and Solanaceae emerged as dominant families. Maurice et al. (1995), while working in the landfills of Sweden, recorded Poaceae, Asterceae, Polygonaceae and Chenopodiaceae as dominant family. In the plants growing on landfill site, some plants showed symptoms of Chlorosis that led to their death. This was probably due to lack of O_2 that would have been replaced by CO_2 and methane, which are abundant gases in MSW landfill.

Conclusion

The present study on plant diversity in landfill site concludes a good number of species (116) growing in relatively small area (4.5 acre). Among the species commercially important species like *Ricinus communis, Achyranthes aspera*, and *Calotropis procera* provide a chance for revenue generation along with phytoremediation. The absence of invasive species like *Eupatorium odoratum* and *Parthenium hystrophorus*

from the landfill site further provide a hope for utilizing this site to grow economically viable species.

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Calendar of Events

2011 International Conference on Environmental Science and Development (ICESD 2011)
7 to 9 January 2011
Mumbai, India
Website: http://www.icesd.org/
Contact name: CBEES Editor
Sponsored by: CBEES,WAU

Asian Pacific Aquaculture
17 to 20 January 2011
Kochi, Kerala, India
Website: http://www.apa2011.org
Organized by: College of Fisheries, Dept. of Fisheries

WATERCON 2011 - International Conference on Community based Water Resource Management
28 to 30 January 2011
Guwahati, Assam, India
Website: http://www.pfifound.org/watercon/
Contact name: Dr Shikhar Sarma
Organized by: PFI Foundation, India/Ministry of Water Resources, Government of India

Water Demand Management in a Changing Climate
1 February 2011
Birmingham, United Kingdom
Website: http://www.lec.lancs.ac.uk/download/water_demand_flyer.pdf
Contact name: R. Alcock
Organized by: Catchment Change Network

Aqua Aquaria India 2011
6 to 8 February 2011
Chennai, Tamilnadu, India
Website: http://www.aquaaquaria.com
Contact name: Mr. Hari
Organized by: Marine Products Export Development of India (MPEDA)

2nd International Conference on Environmental Science and Technology (ICEST 2011)
26 to 28 February 2011
Singapore
Website: http://www.icest.org/
Contact name: Conference Secretary
Sponsored by: CSU, IACSIT, Unisa

4th Annual Produced Water Management Summit
27 February to 2 March 2011
Cairo, Egypt
Website: http://www.producedwatersummit.com
Contact name: Anthony Permal
Organized by: IQPC Middle East

International Conference on Water Resources Engineering & Management 2011
7 to 8 March 2011
Lahore, Punjab, Pakistan
Website: http://www.uet.edu.pk/Conferences/icwrem2011/
Contact name: Prof. Dr. Habib Ur Rehman
Organized by: University of Engineering and Technology, Lahore, Pakistan

Water Innovation, Technology and Sustainability (WITS)
17 to 19 March 2011
Sao Paulo, Brazil
Website: http://wits2011.mgt.unm.edu/
Contact name: Raul De Gouvea

Air and Water Components of the Environment
18 to 19 March 2011
Cluj-Napoca, Cluj, Romania
Website: http://aerapa.conference.ubbcluj.ro
Contact name: Horvath Csaba
Organized by: Babes Bolyai University Faculty of Geography and Romanian National Water Authority, "Somes-Tisa" Branch

15th International Water Technology Conference
31 March to 2 April 2011
Alexandria, Egypt
Website: http://iwtc.info
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