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Planting Indian trees for their ecological services

P.J. Sanjeeva raj*

"A man doesn't plant a tree for himself. He plants it for posterity"

- Alexander Smith

Vegetation (flora) has been the providential co-inhabitants and eco-balancers of all the activities of animals (fauna) and humans on this planet Earth. However, with the lopsided increase of human population and their devastating deforestation, this balance and harmony have been disturbed cataclysmically, a truth that is realised after several centuries. In order to restore that eco-balance, greening the planet by tree-planting has assumed a major eco-restoration priority, the world over.

Several organisations in India today are launching massive tree-planting programmes, on a war-footing, but we must have basic knowledge about the ecosystem functions or services that each species of tree offers, to choose the right species for our specific needs or objectives. They should be indigenous species but a few naturalised helpful species also may be chosen. The chief aim of this paper is to introduce trees for their ecological services or functions also, in our tree-planting programmes.

All vegetation, particularly trees render either ecological as well as economic services or functions, and it is but natural that some species of trees render more, or some render less of such services. Hence greening programmes need to be highly selective to choose the right species of trees, suited for the geographic location, climate, soil and water of the target sites. In the tropical India, we are fortunate to have several wonder or miracle trees of great ecological significance.

* *I am grateful to Dr. P. Dayanandan, for reading through this paper critically and for making valuable suggestions.*

Trees preferred in ancient India

In ancient India, most of the 'sacred trees' and 'sacred herbs' respected were basically those that render unique ecological services, in addition to some economic services too.

Emperor Asoka (265-238 BCE), while crusading for the plantation of trees along roads, was chiefly guided by his humanitarian mission that he was committed to, after his turning point at the Kalinga war. He chose trees chiefly for religious (Buddhist) reverence and also for their medicinal values, especially for the poor.

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The ashoka tree (*Saraca indica*) under which Buddha was born, the Pipal tree (*Ficus religiosa*) under which Buddha attained his Nirvana or spiritual enlightenment, and others like the Sal tree (*Shorea robusta*), the Arjuna tree (*Terminalia arjuna*) and the Naga Tree or the Indian Rose-Chestnut (*Mesua ferrea*) for their medicinal values, were some of the choice trees of Ashoka.

In the recent India, even before the Van Mahotsava or the annual festival of tree-planting was introduced in 1950 by the then Union Minister for Agriculture, Dr. K.M. Munshi, our Nobel Laureate Rabindranath Tagore had the vision in 1928 itself to found the annual tree-planting (Briksharopana) in Bengal, at Santhiniketan where for every fresh sapling planted, he prayed:

"O sky!
Watch this green life with your keen eyes
Let your blessing rain down
To give completion to this young plant!"

Ecologically Preferred Indian Trees

The earlier mythical and material (economic) values of trees are giving way to their ecological values today, and will be much more so, in the future.

Some of the vital ecological services of the Indian trees considered herein are copious oxygen release, carbon dioxide sequestration, absorption of gaseous pollutants, and adsorption of particulate pollutants and promotion of biodiversity. Details of the Economic services from trees are omitted herein, since they are well known to everyone, particularly to the rural people who are 'eco-societies', living closer to nature.

I. Precocious Oxygen Releasers

Oxygen, the gas indispensable for life on earth is generated by all chlorophyll-bearing green vegetation on land and in water, through photosynthesis. However, the following two Indian trees are precocious for releasing oxygen.

1) Neem or Margosa (*Azadirachta indica*):

Neem is one of the wonder trees of India. It is the best air-purifier. Besides releasing high quantities of oxygen, both during the day and at night uniquely, neem filters air by trapping dust and other particles and it even absorbes the gaseous pollutants like sulphur dioxide (SO_2). Neem is a wind shield too. Neem oil is an insecticide as well as a fungicide. NEEM FOUNDATION in India promotes the several economic products of neem.

2. Pipal (*Ficus religiosa*):

Pipal that grows on other host trees like usually the Palmyra palm, as an epiphyte, is said to have the unique gift of releasing oxygen at night also, through the Crassulacean Acid Metabolism (CAM) type of photosynthesis.

Once the epiphyte becomes independent from the host tree and gets rooted in the ground, its CAM type of photosynthesis is given up and it takes over the normal C3 type of photosynthesis, which operates only during the sunlight of the day.

Pipal is a classical Indian tree from the ancient times, known for its cooler shade and for its succulent fruits for birds, during summer.

II. Carbon Dioxide Sequesters

Surplus quantities of carbon dioxide released into the atmosphere, since the Industrial Revolution (18th Century), seems to be the starting point for our current global ecological crisis, what is called as the "Greenhouse Effect", or the "Global Warming", and in general, as the "Climate Change".

Ecologically, capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere is referred to as "Carbon Sequestration".

Different species of trees have different potentials for carbon sequestration and hence mitigating the alarmingly escalating levels of the atmospheric carbon, choosing tree-sapling species that have higher potentials as "Carbon Sinks" is a global eco-restoration priority, today. The following Indian trees (as per the Google Literature) have been intensively studied in the field for a considerable period and are recognised as efficient carbon sequesters. Some of their economic services also are added herein, to help in our preferring them as multi-purpose trees.

1. Drumstick tree (*Moringa oleifera*):

Drumstick tree is a miracle tree for carbon sequestration. It is amazing that drumstick is said to be about 20 times more efficient than other trees in carbon sequestration. Economically also, this happens to be a multi-purpose tree, with its leaves and pods rich in proteins, vitamin C and A, used for curries in India. Its seeds are yields what is called the Ben Oil, rich in omega-3 fatty acids and antioxidants. It's a hardy tree and can be propagated through cuttings also.

2. Neem or margosa tree (*Azadirachta indica*):

Neem is one of the best trees next to the drumstick tree in its efficiency for carbon sequestration. Its other multiple attributes are described under neem as an oxygen releaser.

3. Siris or the Parrot tree (*Albizia lebbeck*):

Besides being an efficient carbon sequestering tree, its roots have the unique attribute of retaining soil-moisture so as to enhance pasture production under the tree. Its shade is said to be cooler than that of the other trees and its foliage is a good fodder for cattle.

4. Gul Mohur (*Delonix regia*):

Its bright orange flowers mark the beginning of the school year in India. They attract several birds and butterflies. The tree is a good carbon sequester too.

5. Yellow Flame tree or the Copper pod (*Peltophorum pterocarpum*):

In addition to being efficient for carbon sequestration, its shade, during the hot summers in India, is cooler than that of the other species of trees in the neighbourhood. Pulicat fishermen take a nap in its shade during the hot summer afternoons, calling this tree as an “A.C. tree”!

6. Tamarind tree (*Tamarindus indica*):

Besides being good at carbon sequestration and a good shade tree, the sour pulp of its pod is used for curries in most homes in India.

7. Babul (*Acacia nilotica*):

It is an excellent tree for carbon sequestration besides providing fodder from its leaves and pods. Excellent timber and also produces resin of medicinal value.

8. Bamboo (*Bambusa bambos*):

There are several species of Indian bamboo and all of them have high potential for carbon sequestration and for storing carbon in the bamboo timber. Bamboo is a multi-purpose wood, used for housing, furniture, handicrafts and for paper production also.

9. Rain tree (*Samanea saman*):

This is a tree naturalised to India, but is ideal for shade along roads and in open spaces. It is a good carbon sequestration tree.

10) *Mahua* or the *Iluppai* or the Indian butter tree (*Madhuca longifolia*):

Apart from being good at carbon sequestration, its flowers are processed for brewing country liquor and its seeds yield oil that has the potential as a biodiesel.

11. Indian beech tree (*Pongamia pinnata*):

Roots help in soil conservation. Oil from seeds is used for lighting, cooking and could be a biodiesel also.

12. Mango (*Mangifera indica*):

Fruits are most relished both by humans and by birds, during summer. Raw mangoes are used for pickle.

13. Banyan (*Ficus benghalensis*):

Most reputed in India for its ever-spreading crown for shade, and its succulent fruit in summer to provide food for birds, starving in the hot Indian summer.

14. Flame of the Forest or *Palas* (*Butea monosperma*):

Glorious orange flower-heads with nectar attract a wide variety of about 31 species of birds. Leaves are nitrogen-fixers and are of medicinal value also. Green leaves are stitched together into eating plates, for one time use.

15. Sisoo or the Indian Rosewood (*Dalbergia sisoo*):

It is an excellent timber tree. Green leaves are good fodder. The leaves are fallen on the ground fix nitrogen, in collaboration with the microbe, rhizobium sp. to enhance the soil fertility. Gives good shade and is a wind shield too.

16. Arjuna Tree (*Terminalia arjuna*):

Since ancient times, *ayurvedic* medicine uses its bark for its antioxidants to treat cardio-vascular diseases and for controlling cholesterol and blood pressure.

17. Sal Tree (*Shorea robusta*):

Reputed for its best quality timber, resin is used in Ayurvedic medicine and oil is used for cooking and lighting.

18. Tendu tree or the Coromandel ebony (*Diospyros melanoxylon*):

Besides good timber, tendu leaves are famous in India for their use in wrapping beedies, the country cigarettes.

19. Teak (*Tectona grandis*):

For Community Forestry in India, teak is the best for carbon sequestration. Teak timber is reputed all over the world, for its use in housing, furniture and for artistic handicrafts, etc.

III. Absorbers of Gaseous Pollutants

1. Methane (CH_4):

Methane also like CO_2 is a primary Greenhouse Gas (GHG), and for shorter duration, it has about 21 times more potential for greenhouse-warming than other GHGs. Liquid sewage, garbage and all decaying organic matters emit methane. The popular Christmas Trees, (*Araucaria columnaris* and *Araucaria heterophylla*) and in fact, all other species of Araucaria are unique in absorbing the atmospheric methane.

2. Ozone (O3):

Ozone (O3) also is also a primary Green House Gases (GHG).

Neem (*Azadirachta indica*), Tamarind (*Tamarindus indica*), *Mahua* or the Indian butter tree (*Madhuca longifolia*), pipal (*Ficus religiosa*) and the Indian Beech Tree (*Pongamia pinnata*) are known to be good at absorbing atmospheric ozone.

3. Oxides of Nitrogen (NO_x) and Sulphur dioxide (SO_2):

Liquid fossil fuels like petrol and diesel, when burnt in automobile engines, release oxides of nitrogen, like Nitrous Oxide (N2O) and Nitrogen dioxide (NO_2), both primary GHGs.

Similarly, wherever coal is burnt as in factories and steam engines, the sulphur content of low quality coal burns, releasing sulphur dioxide. This is a secondary (synthetic) GHG.

African Tulip (*Spathodea companulata*), *Poovarasa* or the Pacific Rosewood (*Thespesia populnae*), Country Almond or the Bengal Almond (*Terminalia catappa*) and the Yellow Flame Tree or the Copper pods (*Peltophorum pterocarpum*) are known to absorb both the oxides of nitrogen as well as sulphur dioxide from the atmosphere

IV. Adsorbers of Particulate Pollutants

New Delhi and other metropolitan cities in India are heading towards an alarmingly escalating level of particulate dust in air, said to be caused chiefly by trucks and other vehicular traffic in our cities. Outside the cities, mining and industrial emissions and occasional dust storms are the cause, leading to severe respiratory problems in humans, forcing them to wear nasal masks.

Neem or Margosa (*Azadirachta indica*) is known to adsorb dust particles to its leaf-surfaces and help to filter the air.

Tamarind tree (*Tamarindus indica*) is another age-old tree in India, believed to be an air-filter. In recent times, the Rain tree (*Samanea saman*) has been introduced for roadside and vacant space plantation, and this also, with its small leaves, like the tamarind, can filter dust from air.

V. trees as biodiversity promoters

The term 'biodiversity' is a recent ecological concept of great futuristic importance. Biodiversity, in brief, means the variety of plants, animals and all other living things. Plants and animals are interdependent for their survival. When any species or communities of flora or fauna are lopsidedly destroyed, the resulting jeopardy of the ecological balances lead to cataclysmic evils like famines, new kinds of health problems, economic bankruptcy and even extinction of vulnerable species. Therefore, it is realised that conservation and promotion of floral diversity is imperative for faunal diversity also. We need to identify such natural inter-relations of plants and animals and promote such trees that attract different species of animals. Trees, birds and butterflies render several ecological services or functions, jointly. Trees provide nectar, fruits, nesting sites, nesting materials, shelter and protection for animals, and animals in turn, help in discharging more vital ecological services like pollination, seed dispersal and pest control.

The following are some such Indian examples of trees providing support to animals:

The flowers of the palasa or the flame of the Forest (*Butea monosperma*) tree, is known to attract at least 31 species of birds for its nectar and petals. Similarly, Banyan (*Ficus benghalensis*) when in fruit, is noted to attract about 15 species of birds, 10 species of insects, two species of fruit-bats, one species each of the squirrel, mongoose, garden lizard and the monitor lizard.

Water bird sanctuaries in India attract birds from not only India but also from far off countries, chiefly to nest and breed in security. The Indian Oak (*Barringtonia acutangula*) in the midst of an irrigation tank, as at Vedanthangal and Nelapattu, and similarly on the babul trees (*Acacia nilotica*) as at the Bharathpur and Koonthakulam bird sanctuaries attract water birds.

These trees offer nesting sites and nesting materials for birds, thus serving the most important biological function of breeding and conservation of populations and species. These birds in turn may drop their excreta or guano into the water to nourish the trees on which they are breeding, year after year, and the birds at the same time, provide another service of wildlife tourism.

Bushy tamarind trees (*Tamarindus indica*) or Banyan trees (*Ficus benghalensis*) or the common fig trees (*Ficus carica*) harbor flying foxes (*Pteropus gigantius*)to roost and breed on these trees. Bat-guano collected from underneath such trees is good for musk-melons, to get their sweet taste.

Wild Date palms (*Phoenix reclinata*) located in water; attract the bayas or the weaver birds (*Ploceus philippensis*) for suspending their intricate receptacle-shaped nests of coconut fibre. Palmyra trees (*Borassus flabellifera*) serve as hosts for the epiphytic species of *Ficus*. Common Crow's nest usually on the neem or margosa (*Azadirachta indica*), and the House Sparrows and Munias habitually nest on the babul trees (*Acacia nilotica*). Butterflies lay eggs and caterpillars grow on specific plants alone.

Thus, some species of animals have their affinity to specific species of trees, which we need to promote.

VI. Recommendations

1) Trees being long-livers and life-givers, tree-plantation in India should no more be routine to plant indiscriminately any trees for shade, flowers, fruits, timber and medicinal values but should be highly selective for their vital ecological services.
2) Continuous research and testing should be done to discover the potential ecosystem services of all the Indian trees.
3) Quality seeds of the eco-trees should be constantly collected and stocked in 'Seed Banks'.
4) Nurseries should grow saplings of such chosen species. Saplings may be donated as charity for schools and bonafide organisations that cannot afford to get the rare and right trees species.
5) The right species of trees to be planted should be chosen according to the ecological need of the target site and also as per the economic needs of the local poor who are the participants in the plantation programme.
6) Plantation of eco-trees should coincide with the stoppage of all emissions of all Greenhouse Gases (GHGs) in the neighbourhood.
7) Neem in India fulfills several ecological and economic needs, so that it might be called as the best "Eco-Tree of the Indian Subcontinent".
8) Plantation, care and enjoying the economic benefits of the eco-trees could be as in Social Forestry, involving the local poor as partners.
9) With the ever increasing Indian industrial and urban development, ecological tree-plantation should be a priority obligation for all, in India.

As a Chinese proverb says:
"The best time to plant a tree, was
twenty years ago.
The next best time is, today!"

Assessment and study of heavy metal contamination of soil and groundwater due to E-waste handling in Mandoli industry area of Delhi, India

Ahmed Sirajuddin[1] & Panwar Rashmi Makkar[2]

Abstract

This paper reveals the magnitude of heavy metal contamination of soil and ground water in and around an unauthorized E-waste recycling site in Delhi. Though unsafe and unorganized e-waste handling is now legally banned in Delhi, still the informal sector is actively involved in carrying out dismantling, extraction and disposal of E-waste at certain places at considerably large-scale. The leachate produced by these recycling units has a large amount of heavy metals which are likely to pollute the groundwater and soil adjoining the recycling sites. The E-waste contamination at such sites was evaluated in this study by monitoring the potential contaminants at a number of specific monitoring points. The soil and underground water qualities are checked for the presence of heavy metals around e-waste recycling and dumping site using Atomic Absorption Spectrometry (AAS). The standard values as per central ground water board were taken as reference values for water, and agricultural soil in Britain as for soil at the e-waste site. It is clear from the results that the groundwater and soil in and around these sites have been found contaminated by heavy metals like lead and copper to a great extent.

Key words: *heavy metals, contamination, groundwater, soil*

Introduction

The Waste Electrical and Electronic Equipments (WEEEs) contain several substances, many of which are toxic and could be hazardous for environment, specially soil and water, whereas precious metals including gold, silver, palladium, tantalum, platinum etc are only present in traces in WEEEs. While recycling in automatic methods, precious metals are lost in bulk of other

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less valuable materials (Chatterjee and Kumar, 2009). Dissolved metals are considered to be the most mobile and thus reactive .These are bio available fractions in an aquatic system and are cause of major concern(Wong et al., 2007).

In this study various sites of e-waste handling and recovery are visited it was found that metal recovery is still taking place in Mandoli, New Delhi, India. Unauthorized e-waste handling is band but it was noticed that at some places waste handling operations remain unchecked and covertly carried out banned activities. The large quantity of e-waste which is dumped after recovery in these areas portrays the real scenario. The samples of soil and water were collected and tested for heavy metal contamination from the identified sites. The testing was done for copper, lead, cadmium, nickel, chromium, and zinc.

Effects of heavy metal contamination

The metals with a density greater than certain value, usually 5 or 6 g/cc (Wild, 1996). The e-waste contamination can adversely affect fertility of soil where it can make water unfit for consumption (Zhang et al., 2012) as heavy metals can leach into soil and water when e-waste is irresponsibly dumped. Increased heavy metal content negatively affects soil microbial population, which may have direct negative effect on soil fertility (Ahmad et al., 2005). Heavy metals released from salvaging useful materials and from open burning could pollute air, soil and water. Plants can take up these metals from roots, transport them upwards to their shoots, and finally accumulate them inside their tissues (Luo et al., 2006). Heavy metals not recovered during WEEE treatment and residual auxiliary substances like mercury and cyanide can leach through the soil after disposal of effluents and from inorganic and organic complexes within soils (Sepulveda et al., 2010). Leaching of heavy metals through the soil prevents plants from absorbing their essential nutrients (Mancuso and Green, 2010), such as potassium, calcium, magnesium, and nitrates. Also, it can disturb the ecological balance of the region by disrupting the growth of microorganisms.

Heavy metals cadmium, zinc, lead and chromium can lead to human poisoning when consumed in drinking water. Consumption of heavy metals causes irregularity in blood composition, badly effect vital organs such as kidneys and liver (Khan et al., 2011) apart from damaged or reduced mental, central nervous function and lowers energy level. The long-term consumption of these metals result in physical, muscular, neurological degenerative processes that cause Alzheimer's disease, Parkinson's disease, muscular dystrophy and multiple sclerosis (Mohod and Dhote, 2013).

Previous studies

Similar study has been carried out in the largest E-waste dumping site in Alaba International market in Lagos, Nigeria, in which concentrations of heavy metals mentioned above were identified in the soil at the site (Olafisoye et al., 2013). In that study, concentration levels of cadmium, chromium, lead, nickel and zinc in water, soil and plants were measured by Atomic Absorption Spectrometry (AAS) using wet digestion method. It was found that concentration levels of heavy metals in consideration exceeded the permissible levels in soil at the site. In China, soils at sites where e-waste is burned (Luo C et al., 2010) was analyzed for quantifying heavy metal contamination levels and soil samples of former incineration sites were found to have exceedingly high levels of Cd, Cu, Pb and Zn. E-waste recycling operations cause appreciable hazards to adjoining soils. In Oman, testing was done for surface and ground water contamination (Al Raisi et al., 2014) at unlined leachate sites of Al Amerat and samples were analyzed for concentration levels of heavy metals in drinking water. Metals like Nickel, Cobalt and lead were found to be in exceeding amount in waste and drinking water. In India, Toxics Link has conducted study at E-waste recycling site in Loni and Mandoli areas in Delhi (Toxics Link, 2014) and has tested for heavy metal contamination of soil and water. Recycling practices at these sites were studied and their effects on soil and water concentrations were analyzed. Soil samples from these sites suggest there has been significant concentration of heavy metals and soil characteristics have changed and hence the correlation between recycling practices at these sites and soil characteristics were established.

Need of study

In India, only a few landfill sites are available for environmentally sound disposal of e-waste. And severe environmental hazards are associated with careless and irresponsible dumping of e-waste that contains several hazardous substances. The entrepreneurs engaged in recycling lack proper technical knowledge and do not have adequate means to handle the increasing quantities nor the expertise for certain recovery processes (Ha et al., 2009). These substances pose serious adverse impacts on soil and water adjoining the site. Not even households, but several industries are involved in such illegal practices and contribute to environmental hazards. The illegal dumping sites are a major issue of concern for India. Quantification of hazardous material contaminating the soil and water at the landfill and recycling sites is significant for environmental organizations and legal authorities in India to pressurize the recyclers for using alternative measures of recycling and disposal. Also, it helps keeping a check on the illegal dumping of e-waste and makes the producers more responsible towards safe disposal of their end of life products. Moreover, the in-complete data on generation and disposal of hazardous substances increase the worry. It is presumed that about 10 to 15 percent of wastes produced by industry are hazardous and the generation of hazardous wastes is increasing at the rate of 2 to 5 percent per year (Trehan, 1992). But, reliable data and exact assessment on quantity of various hazardous wastes generated is not available as yet. Therefore, scientific disposal of E- waste has become a major challenge in India.

WEEE is one of the most complex waste streams requiring proper management. To meet the challenge associated with disposal of waste from electrical and electronic products, the Central Pollution Control Board in India has issued guidelines for environmentally sound management and handling of e-waste that came in effect from 1st May 2012 (MoEF, 2010).

Material and Methods:

Study area

The selected site for this project was Mandoli industrial area in East Delhi as it is one of the hubs of unorganized and uncontrolled e-waste handling (Gidarakos et al., 2012) and dumping in Delhi. The area of interest can be located as having western borders approaching the river Yamuna and southern border meets Mangal Pandey Marg in Mandoli (Figure 1), while North and Eastern sides are densely populated zones. The area is swamped with small one or two room unauthorized E-waste recycling units (MMA, 2008) in which majority of the population finds employment. The informal e-waste recycling sites discharge their effluents into open lands in the absence of drains and solid waste is disposed by open burning. In Mandoli, there are 6 companies running since year 2000 which recover copper by burning Printed Wire Boards and nearly 3000 kg of PWBs are burnt per day (Malik, 2004). Also, large dumps of waste of electronic products are lying openly on the roadsides, which were witnessed during personal visits. Ground adjoining to farm land is also used for disposal of e-waste. Thus the effluents are directly discharged into land directly impacting soil and ground water. The area is densely populated and the use of underground water is very common by the residents of this area and surrounding localities. The scope of this study is restricted to soil and water contamination by heavy metals released as e-waste disposal after recycling and extraction.

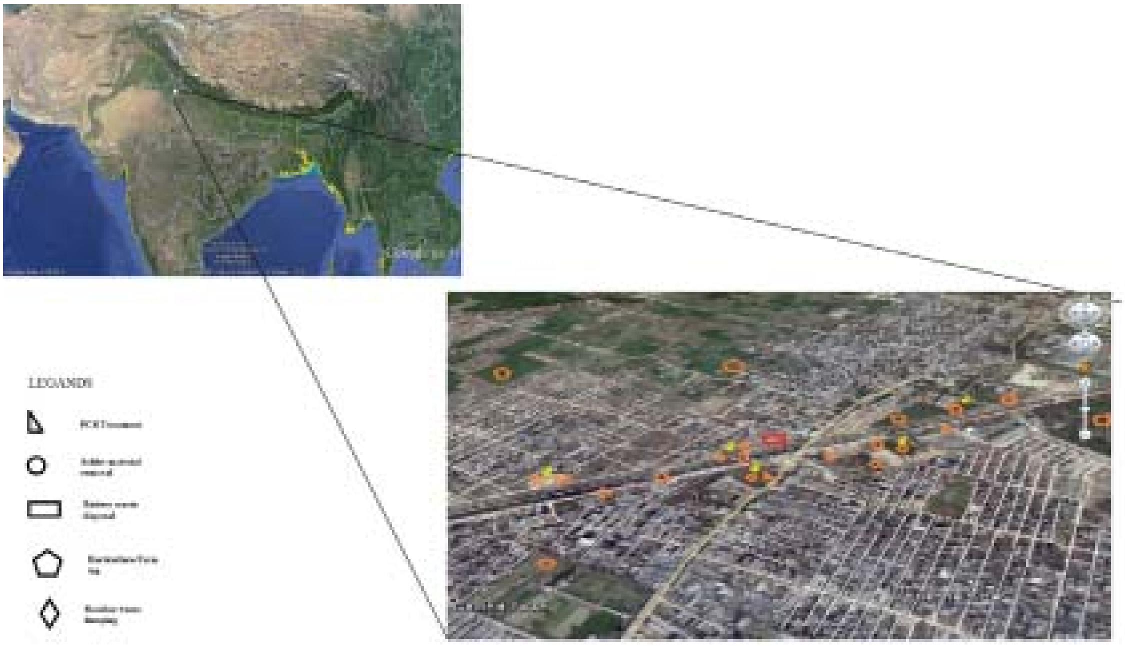

Figure 1: Potential e-waste area showing sites and activities

Soil and water sampling

All the soil and water samples were collected in December 2013. Soil samples: 10 top soil samples from ground level and 10 sub-surface soil samples were taken from about 60 cm deep soil. The collection of samples is done from various locations in Mandoli. Reference soil samples were taken from the locality 5 Km. away from e-waste handling units. All the samples were collected using stainless steel spade and were put in plastic containers. Samples of underground water were also collected to assess the effect of heavy metals released from e-waste recycling unit on the groundwater. Water samples were collected from hand pumps located in the vicinity of dumped e-waste and reference samples were collected from the areas 5 km away from active sites for comparison of the heavy metal content of all the samples. Water samples were taken in clean plastic one liter bottles and were tested using Atomic Absorption Spectroscopy after digesting with HNO3. A conventional wavelength-dispersive X-ray fluorescence spectrometer was used for AAS (Kawai et al., 1998), as it has high energy resolution and short measuring time.

Sample analysis

Soil samples were collected and investigated for presence of heavy metals and standard procedures as indicated in Table 1 were used for soil analysis.

Table 1: Standard procedure used for sample analysis

S.No	Parameter	Method of Analysis	Unit	Procedure	Analyzed Substances
1	Copper	APHA 3120-B	mg/kg	Digestion with HNO_3, AAS (Atomic Absorption Spectrometry)	Soil and water
2	Lead	APHA 3120-B	mg/kg	Digestion with HNO_3, AAS (Atomic Absorption Spectrometry)	Soil and water
3	Cadmium	APHA 3120-B	mg/kg	Digestion with HNO_3, AAS (Atomic Absorption Spectrometry)	Soil and water

S.No	Parameter	Method of Analysis	Unit	Procedure	Analyzed Substances
4	Nickel	APHA 3120-B	mg/kg	Digestion with HNO_3, AAS (Atomic Absorption Spectrometry)	Soil and water
5	Chromium	APHA 3120-B	mg/kg	Digestion with HNO_3, AAS (Atomic Absorption Spectrometry)	Soil and water
6	Zinc	APHA 3120-B	mg/kg	Digestion with HNO_3, AAS (Atomic Absorption Spectrometry	Soil and water

Results and discussion

The soil samples collected from the e-waste site and reference site after investigation yielded the results as shown in Table 2. The concentration levels of heavy metals in top soil and sub-soil samples of the e-waste and reference sites are indicated below. The values indicated are the average values for metal concentration. The standard values for metal concentrations in soils are those for agricultural soils in Great Britain (Davies and Ballinger, 1990). To evaluate the extent of heavy metal contamination in soil, the concentrations in collection sites samples were compared with reference soil samples and soil guidance given by standards for agricultural soils in Great Britain. The comparative analysis for average values of heavy metals composition evaluated for Top soil and sub soil samples of E-waste sites and reference sites is depicted in table 2.

Table 2: Heavy metal concentrations (mg/kg) in soil samples of different sampling sites

Site	e-waste site		Reference site		Agricultural soil (in Great Britain)
Heavy Metal	Top soil	Sub soil	Top soil	Sub soil	Standard
Cu	238.23	73.04	8.39	0.58	100
Pb	298.10	183.54	12.50	0.43	100

Site	e-waste site		Reference site		Agricultural soil (in Great Britain)
Heavy Metal	Top soil	Sub soil	Top soil	Sub soil	Standard
Cd	47.77	19.16	0.26	0.00	3
Ni	41.44	40.14	7.66	0.00	50
Cr	145.18	80.53	6.99	0.1	50
Zn	174.83	65.11	9.69	0.30	300

Soil Contamination

The mean heavy metal concentrations of soil samples collected from e-waste handling sites and reference sites are shown in Table 2. To evaluate the extent of heavy metal contamination in soil, the concentrations were compared with reference soil samples and soil guidelines given by standards for agricultural soils in Great Britain. The average concentrations were copper 238.23 mg/kg, lead 298.10mg/kg, cadmium 47.77mg/kg, nickel 41.44mg/kg, chromium 145.18mg/kg and zinc 174.83mg/kg in top soil samples (see figure 2). The average concentration of copper, lead, cadmium and chromium topsoil samples from e-waste sites are far above the range for standards of agriculture soil and exceeds the permissible limits. The concentrations of all these heavy metals are much higher than the reference site concentrations also. The average copper concentration is nearly 30 times as compared to reference sites top soil samples and nearly 120 times for sub soil samples. Copper is associated with organic matter, oxides of iron and manganese, silicate clays and few other minerals. It builds up in the surface of contaminated soils showing almost no downwards migration (Parth et al., 2011). The major reason of the high copper concentrations in all the soil samples is caused due to copper extraction from printed wiring boards, which is one of the major activity carried out in the area.

Printed circuit boards, wires and lead batteries are treated at sites of selection, hence it becomes important to study the impact of lead on soil and water in surrounding area lead is used in electric solder, primarily on printed circuit board. The average lead concentrations were found to be 298.10 mg/kg in top soil samples and 183.54mg/kg in sub soil samples of e-waste handling sites which are almost three and two times higher than the standard concentrations. Reference soil concentrations are considerably very low as compared to sites concentrations. Lead (Pb) in soil exists in the +2 oxidation state. As soil pH rises; $Pb2^{+}$ ion becomes less soluble under oxidizing conditions. Metallic lead has been used in electric solder, commonly as an alloy with tin and lead compounds have been commonly used as stabilizers in PVC (Polyvinyl chloride) formulations (OECD, 2003).

Average concentrations of cadmium in top soil samples is 16 times higher than that of agricultural standards and

6 times higher than in subsoil samples, where the reference site samples have negligible cadmium concentrations at an average of 0.26 mg/kg. Cadmium and its compounds are used in a number of applications within electrical and electronic products (Shankar et al., 2005).

The average concentrations of nickel in top soil and sub soil are nearly same at 41.44 mg/kg and 40.14 mg/kg .The average values are within the threshold limit of 50mg/kg, however the average concentrations level exceeds the average reference values.

Average concentrations of chromium in topsoil samples is 145.18 mg/kg which is approximately 3 times higher than the standard limit and 20 times higher than the reference value. Average concentration in sub soil samples is also 1.5 times than standard limits and 800 times than the reference site subsoil average concentration. Waste from lead-chromium batteries, coloured polythene bags, discarded plastic materials and empty paint containers are said to be huge source of chromium (Matthews, 1996).

Average concentration of zinc was found to be within the limits of standards for agricultural soil.

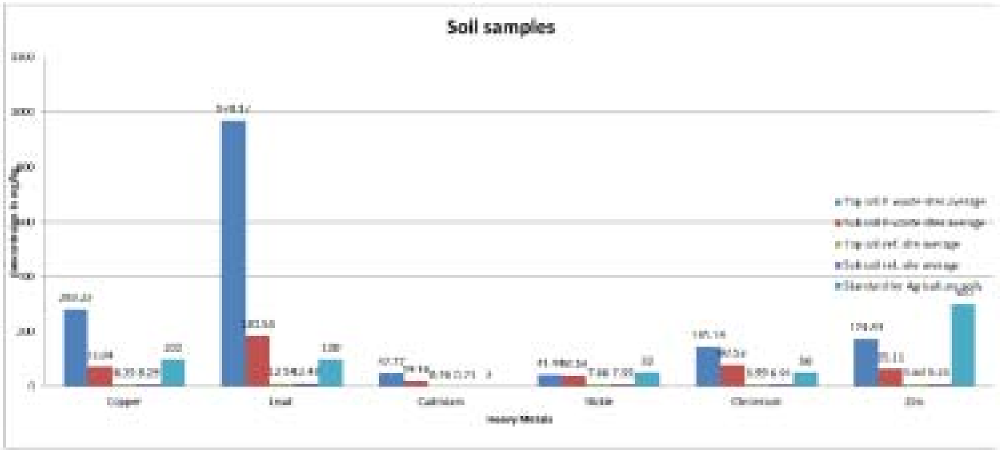

Figure 2: Heavy metal concentrations in soil samples
Heavy metal concentrations (mg/kg) in soil samples of different sampling sites

The average concentrations were copper 238.23mg/kg, lead 298.10mg/kg, cadmium 47.77mg/kg, nickel 41.44mg/kg, chromium 145.18mg/kg and zinc 174.83mg/kg in top soil samples. The average concentration of copper, lead, cadmium and chromium topsoil samples from e-waste site are far above the range for standards of agriculture soil and exceed the permissible limits. The concentrations of all these heavy metals are significantly higher than the reference site concentrations also. The average copper concentration is nearly 30 times as compared to reference sites top soil samples and the average lead concentrations were found to be 298.10 mg/kg in top soil samples, which is almost three times higher than the standard values.

3.2 Water contamination

The results of water samples collected are as shown below in table 3.

Table 3: Heavy metal concentrations (mg/kg) in water samples of different sampling sites

Heavy metals	E-waste site	Reference site	Standard*
Cu	1.465	0.18	0.05
Pb	1.25	0.0075	0.05
Cd	0.28	0.00	0.01
Ni	0.29	0.003	0.05
Cr	0.008	0.008	0.05
Zn	0.16	0.016	5.00

*Drinking water standards as per central ground water board (Shekhar, 2012)

The average concentration of copper in water sample is 29 times higher than the water standards and 8 times higher than the reference water levels. The average lead concentration is 25 times the threshold value. Cadmium concentration in reference samples is 0 because the average value of cadmium is 0.28 mg/.lit. The threshold limit for drinking water is 28 times lower than this value making this water highly unsafe for drinking. Average Nickel concentration is 0.29mg/lit which is exceeding the threshold value of 0.05 mg /lit. The average concentration of chromium is 0.83mg/lit and the reference water samples average is far less at 0.008 mg/lit (see figure 3). This value also exceeds the drinking water limits. It has been observed that the concentrations of all the heavy metals found in water samples were more than the permissible limits and the reference water sample concentrations.

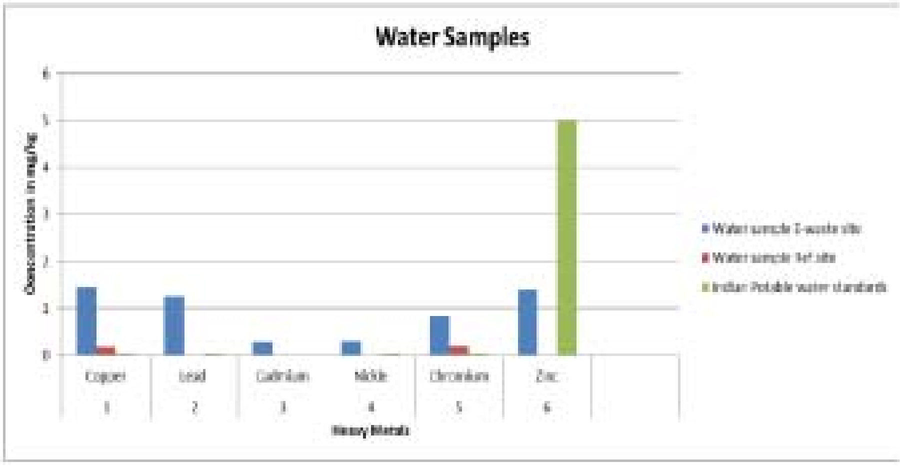

Figure 3: Heavy metal concentrations (mg/kg) in water samples of different sampling sites

Statistical analysis

There were significant associations between cadmium and copper ($P<0.05$), chromium and lead ($P<0.05$) in soil samples. The correlation coefficient is also significant for cadmium and copper ($P<0.05$) and chromium and nickel ($P<0.05$) in water samples. The findings for correlation coefficients of metals in soils and water are shown in table 4 and table 5 respectively. This suggested that more cadmium concentrations are associated with higher values of copper concentrations in soil as well as water samples. Significant correlations between metals shows a common source. The results of testing for various samples are compiled in table 4 and table 5.

Table 4: The correlation co-efficient of metals in soils

	Cu	Pb	Cd	Ni	Cr	Zn
Cu	1					
Pb	-0.035	1				
Cd	0.895*	-0.203	1			
Ni	0.569	0.0435	0.604	1		
Cr	0.343	0.766*	0.276	0.063	1	
Zn	0.057	-0.014	-0.058	-0.065	0.125	1

* Correlation is significant at $P<0.05$

Table 5: Correlation co-efficient of metals in water

	Cu	Pb	Cd	Ni	Cr	Zn
Cu	1					
Pb	-0.096	1				
Cd	0.977*	-0.266	1			
Ni	0.682	0.155	0.578	1		
Cr	0.611	-0.048	0.568	0.885*	1	
Zn	-0.109	0.468	-0.222	0.432	0.048	1

* Correlation is significant at $P<0.05$

Conclusion

This study shows that the average concentrations of copper, lead, cadmium and chromium of all topsoil samples fall out of the range for standards of agriculture soil and exceeds the permissible limits and are much higher than the reference site concentrations. Nickel concentration is within limits in soil samples but in water it is about 5 times higher than potable water standards. Copper concentration is more than 2 times higher than the standard limit in top soil samples and alarming at a level of 1.46 mg/kg in water samples as Indian potable water standards are 0.05mg/kg. Average lead concentration in soil is about 3 times higher than the standard limit while in water samples it is 25 times higher than the potable water limits. Average cadmium concentration in soil is 16 times higher than standard limits and in water it is 29 times higher than that of Indian potable water standards. Chromium concentration is about 3 times higher than the standard limit and 16 times higher than the potable water limits. Zinc concentration is within prescribed limits for soil and water samples.

Testing and analysis of water samples clearly indicated that the presence of heavy metals in all the underground water samples which also exceeds the limits for drinking water. The water of these areas is not suitable for drinking. The findings clearly indicated the contamination of soils due to heavy metals released during processing of e-waste and it provides useful baseline information on e-waste contamination for soil. The emission of heavy metals and the risk for the health by direct exposure or by bio-accumulation and geo-accumulation is of great concern. In addition to consumption of water local inhabitants are also susceptible to acid fumes, ingestion of heavy metal contaminated dust and toxic gases on account of e-waste recycling practices carried out around this area. These findings point towards the requirement of better monitoring and enforcement of laws to control informal and improper handling.

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A Study on Awareness of E-waste and its Implication in Ahmedabad

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Abstract

Electronic waste (E-waste) is relatively a recent addition to the hazardous waste stream in India which is one of the reasons why the community is not aware about the process to handle, manage, and dispose of the waste or as the case in this paper even heard about the term and what it means. This paper tries to analyze the awareness level of issue of e-waste management in the city of Ahmedabad. The purpose of this study was to analyze knowledge, disposal methodology and attitude of citizens towards e-waste in their homes. The sample size of the survey was 5500 which was conducted between August to October 2013 by approximately 3900 students (grade 5-12) from 8 schools by personal interview methodology of their parents and neighbours as a part of an education for a sustainable development project in Ahmedabad. The study concluded that 43 percent of citizens surveyed had not heard about e-waste before and 12 percent did not know how to handle after life e-waste, 20 percent thought disposing in dustbin was the right method. The education programmes need to focus on raising awareness on e-waste rules and implementation systems, extending the life cycle of the products by donation and repairs and reduce consumption.

Introduction

As per the E-waste (Management) Rules 2016, 'e-waste' means electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment and repair processes (MoEFCC, 2016). Technological advance and rapid product obsolescence is the new environmental challenge authorities are facing in order to manage and dispose e-waste. E-waste is considered dangerous upon open disposal, as certain components of electronic products contain materials that are hazardous to the environment as well as to human health. (Rao, 2014)

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E-waste scenario in India

The growing IT / consumer electronics sector is one of India's trademarks with growth rates of 42 percent between 1995 and 2000 (Toxics Link, 2003). As an outcome of rapid growth, the access to electrical and electronic equipment has steadily increased in the past few years. In 2014, the amount of global e-waste reached 41.8 million tonnes according to a new United Nations University report (Baldé, 2014). India generates about 0.4 million tonnes of waste annually (from computers, mobile phones and television sets only) with an expected growth rate of 10-15 per cent per year (Toxics Link, 2013). As per the Ministry of Environment, Forests and Climate Change, the E-waste generation is about 1.7 million tones with an annual increase of 5 percent.

Almost every task involved in waste management – collection, transportation, segregation, and dismantling – has been carried out by the unorganized sector in India (Wath et al., 2011). The lack of government regulation has allowed for the growth of an informal economy that provides a livelihood for the urban poor. However, rudimentary handling methods increase the severity of this health and environment-related problem (Wath et al., 2011). Additionally, as the-waste Electrical and Electronic Equipment (WEEE) supply grew in India over the past 15 years, the previously existing scrap metal industry began to collect, dismantle, sort, and recycle e-waste. Yet the same practices used for material extraction in regular waste were being applied here, presenting a multitude of occupational hazards (Borthakur and Sinha, 2013). Current practices include open burning of plastic waste, use of toxic solders, dumping of acids, and widespread general dumping. Most of this work is done without Personal Protection Equipment (PPE), and carried out under poor lighting and insufficient ventilation (Wath et al., 2011). According to Greenpeace, businesses often encourage this work by selling discarded electronic equipment to informal recyclers for quick money, without realizing the hazardous implications for human health and the environment.

The unorganized sector processes far more e-waste than does the formal sector – 2012 estimates show that 95 percent of e-waste is handled by informal workers (Borthakur and Sinha, 2013). There are currently over 2,000 informal recyclers in India, and Gujarat ranks among the top states for this practice. Generally, formal sector e-waste plants only carry out segregation and dismantling, leaving the recycling and final disposal of e-waste to the informal sector, or sending it to foreign countries. (Agrawal, 2012).

Kwatra et.al. (2014) in a survey conducted in Delhi revealed that a significant fraction of middle-class population is still unaware of the issue. For those who knew about it, the main sources of information to them were found to be internet, and print media. However, despite some awareness about the issue, most respondents were totally unaware about correct ways of its recycling and management. An important finding of the study was that 12-26 percent of the people replace their major electronic goods like refrigerators, food processors, personal computers and music systems within the first three years of purchase. The survey also revealed the willingness of users to pay extra cost for proper management of e-waste provided that there is proper cost sharing between consumers and producers.

Shah et.al. (2014) found that most respondents do not participate in formal e-waste recycling systems, do not know specific details about the health and environmental hazards of e-waste, and were not aware of the 2011 e-waste legislation. Additionally, only about one quarter acknowledge the possibility of extracting raw materials or spare components from unused electronics. Nearly half of respondents above the age of 30 stated that they knew of e-waste hazards without indicating knowledge of specific hazards, while only a fifth of respondents under the age of 30 exhibited this behaviour. Thus, there appears to be greater reluctance among the older generation to admit a lack of knowledge. Additionally, it seems that the younger generation is far more aware of the environmental risks to the growing amount of e-waste in India. In contrast, a greater percentage of the older age group than the younger group knew of formal e-waste processing services, and both age groups had an equal percentage of respondents who knew of informal services. Thus, it seems that the younger generation knew more about e-waste hazards, while the older generation has a greater awareness about methods of disposal.

Methodology

The study was carried out as part of Education for Sustainable Development programme of the Centre for Environment Education on the issue of e-waste with schools in the city of Ahmedabad. The programme based on project based pedagogy learning had the steps of Explore, Discover, Think and Act. The survey was part of the first two steps to help children and teachers explore and discover the issue of E-waste before they start any action to mitigate the impacts of E-waste.

A survey questionnaire was designed to collect information for inventorization of the e-waste at homes and understand the behavior with regard to such waste. The survey was made available both in English and Gujarati. The questionnaire had both open ended and close ended questions with multiple options to choose from for most of the questions. The description of the questionnaire is given Table 1. The entire survey was done by students with the help of teachers.

Table 1: Description of the survey questionnaire

Section	Description of questions
Details of the respondent	Name, Contact Address, Phone no., E mail id
Inventorization of e-waste	Detail of electrical/electronic appliances, condition (Broken, repairable, working but not used), Count of each waste.
Knowledge and Behaviour	Awareness regarding the word e-waste, source of awareness, behaviour with old on buying new, the reason for keeping e-waste at home, does *kabadiwala* (scrapdealer) ask for waste, awareness about how e-waste is managed in Ahmedabad, their opinion on how best to manage e-waste, knowledge about materials/component that can be sourced / re cycled from e-waste.

The questions in the survey as described in Table 1 had some suggestions for response but with flexibility to record other suggestion. The teachers from the school were oriented on the purpose of the survey and taken through each section in a joint meeting. The schools volunteered to be part of the exercise.

The survey was conducted by students of grade 5 to grade 12 in eight schools in Ahmedabad ranging from various educational boards where the language of teaching was English and Gujarati. Approximately 3900 students took the initiative to be a part of this study and conducted the survey in their own homes and 1-3 neighbours' homes. Personal interview method was used to collect the information.

Study site

Eight schools in different parts of Ahmedabad participated in the survey. Ahmedabad is the largest city and former capital of Gujarat. With a population of more than 6.5 million, it is the sixth largest city and seventh largest metropolitan area of India. Ahmedabad is located on the banks of the Sabarmati River, 30 km from the state capital Gandhinagar. Ahmedabad has emerged as an important economic and industrial hub in India. The effects of liberalisation of the Indian economy have energised the city's economy towards the tertiary sector of the economic activities like commerce, communication and construction. In 2010, it was ranked third in Forbes's list of fastest growing cities of the decade. In 2012, The Times of India chose Ahmedabad as the best city to live in India.

Sample

The survey was conducted by eight schools participating in the programme.

A total of 5500 interviews were conducted by children across Ahmedabad city. The study was done between August to October 2013.

Data analysis and findings

The data was analyzed by both qualitative and quantative techniques. The quantitative analysis was done by using Microsoft excel. For the purpose of analysis the city was divided into six zones based on the location of the school and assuming that the majority of them would be residing in the nearby areas. The clustering is based on the zoning done by Ahmedabad Municipal Corporation for administrative purpose; the zones are called Central, East, North, South, West and New West. The city is divided into two parts by the Sabarmati river, east being the old city area while west being the suburb and new commercial area. The west and new west zones have flourished in the last 2 decades with the majority of the residents being migrants having industries in nearby areas and proximity to the highway. The majority of residents in this zone are educated from affluent socio economic background. The south and north zone are comparatively less affluent and have a lot of is SMEs on the outskirts. While the east and central zone are part of the old city area. 71 percent, is of the respondents in this survey were from West and New West zone. There were no respondents in the north zone.

Findings and Discussions

The awareness about e-waste was found to be present in only 43 percent of the total respondents. The test results came as a surprise as social media, print media and the local municipal authorities have been conducting various activities for e-waste awareness. As we see in Figure 1, East zone and south zone had the maximum respondents with 67 percent and 62 percent being not aware of E-waste. New west zone and west zone respondents were more aware of E-waste and this could be because of more affluence and higher use if electronics and electrical equipments. Central zone had about 58 percent respondents being aware of E-waste and one of the plausible reason could be that many people in this area are engaged in waste trading.

Handling of e-waste at home

In order to know the attitude of citizens towards an old electronic items, a question was formulated to know how they have handled it after new electronic/electrical appliance was purchased. The response was different depending upon the various zones of the city.

Figure 1.1 The response to awareness on E-waste

Table 2: Handling behavior of E-waste

Response	Response according to Geographic zone in %				
	New West	West	Central	East	South
Threw it	3	4	5	0	11
Kept in cupboard	14	9	22	17	11
Gave to *kabadiwallah*	20	19	18	0	0
Donated	15	12	14	17	11
Sold to someone	12	11	18	0	17
Replaced in a exchange scheme	18	17	9	17	11
Gave to family/friends	11	22	9	17	33
Repaired Others	7	6	5	32	6

In the new west zone 20 percent respondents said they gave old items to the *kabadiwallah* while 18 percent exchanged the old items during exchange schemes. While 12 percent of them sold it, 15 percent donated it to their maid or nearby school. However only 7 percent got it repaired while 3 percent threw them in the dustbin. In the west zone 22 percent respondents said they passed on their old electronic items to family members. But the percentage of selling in buy back schemes and giving it to the *kabadiwallah* still remained high with 17 percent and 19 percent respectively. Only 6 percent respondents got it repaired while 4 percent threw it into dustbins.

In the central zone 22 percent respondents said they stored it in their house, while 18 percent said they sold it sometimes to family, neighbours or friends. Another major chunk was 18 percent respondents who gave the e-waste to *kabadiwallahs*. Only 5 percent got it repaired and 5 percent threw it in the dustbin. In the east zone a whopping 32 percent respondents said they repaired old electronics while the rest said they stored it, donated it, exchanged it in buy back schemes or passed it on in family. In the south zone 33 percent respondents passed it on to family members, 17 percent sold it and others sold it in exchange schemes, stored it or donated it. However 6 percent got it repaired.

This is an interesting aspect to analyze as the communication strategy has to address various issue and there is definite soci-cultural aspect attached to the behavior. West and new west zones which had maximum respondents gave it off to the *kabadiwallahs* and very few people tried to revive them by repairing it. The area is affluent and people tend to change their equipment. In the subsequent e-waste collection drives, the students collected many equipments disposed off for minor faults. The population needs education with the key message for encouraging them to increase the life of the product by repairing, exchange or donating it.

While the east and central zone being a less affluent zone it was observed that the tendency was towards reusing it by giving it to family, repairing and storing it in the house and repairing it later on. The E-waste collection drive by the students resulted in very less amount of e-waste and most of it was very old and non repairable. The communication in this required was end of life disposal by giving it to authorized recycler

Storage of e-waste

It was also observed that many respondents had kept their e-waste especially old mobile phones, personal computers, electrical wires for long period in their homes. Various reasons were given by the respondents on why they had stored it and not sold/ donated/thrown it.

Table 3 : Storage of e-waste

Options	Response according to Geographic zone in %				
	New West	West	Central	East	South
Don't want to sell	5	9	0	0	21
Not getting good price	6	13	6	0	21
Don't know what to do	15	9	6	0	7
Planning repair	13	9	32	60	30
Gifted and hence sentimental value	40	40	22	0	14
Doesn't bother me	11	10	17	0	0
Others	10	10	17	40	7

In the west and new west zone 40 percent respondents said they had memories attached with the product and did not intend on selling/ donating/recycling it. While 10 percent on an average said they were planning to get it repaired. 10 percent said it did not bother them while 12 percent said they did not know what to do with it. In other other areas of the city most respondents said they were planning on getting the e-waste repaired while for others it did not bother them. In the south zone, 21 percent respondents showed eagerness to give it to recycler but claimed that they were not getting a good price for it. This needs to be explored as storing the appliances does not become e-waste and cause any environmental hazard. For residents who did not know what to do with e-waste, a major awareness campaign is required in the area about e-waste handling, reuse, repair and disposal.

Table 4 : Disposal of e-waste

Options	Response according to Geographic zone in %				
	New West	West	Central	East	South
Sell	17	14	0	0	28
Throw in dustbin	20	22	0	0	0
Burn	3	4	0	0	14
Donate	48	54	53	25	29
Give it to authorized recycler/collector	12	6	47	75	29

In order to understand the knowledge and attitude of the respondents a question was devised about the right way of disposal of e-waste according to them. On an average 45 percent citizen from all zones talked about donation.

In the west and new west zone which has higher education levels, 10 percent of them said it should be given to an authorized recycler and 15 percent said it should be sold off in second hand market or buy back schemes. However, 20 percent citizens also said it should be thrown in the dustbin and 4 percent even said to burn it is the right way of disposal. The lack of right way to dispose and harm it causes to the environment is lacking and it is required as an important part of any education programme on E-waste.

In the east zone 75 percent respondents said the right disposal was giving it to the authorized recyclers while 25 percent said donation was the right choice. In the south zone 29 percent respondents thought that the right disposal was authorized recycler followed by 28 percent selling and 29 percent donation. However, 14 percent said burning was the right choice. In the central zone 53 percent said donating was the right choice while 47 percent said giving to an authorized recycler was the right choice. Extending the lifecycle through donation is a good strategy and it might be because as the value realized from giving it to the recycler is less than the perceived value. Donation is a good option but it also matters how efficient that appliance is. In case of air conditioners older than 10 years, the appliance becomes energy inefficient, ultimately using a lot of electricity.

Kabadiwallah's role

During research it was found that in many cities of India, the *kabadiwallah* or the informal sectors plays an important role as they ask for e-waste from homes. In the questionnaire, it was decided to address this question to know the scenario of Ahmedabad. On average 80 percent respondents said the *kabadiwallah* in their area never asked them to give old electronic/ electrical appliances in exchange of cash. In the south zone the ratio of *kabadiwallah* asking for e-waste was highest with 39 percent while in the east zone there was no *kabadiwallah* asking for e-waste. This needs further exploration. The education/ communication has to focus on informing the collection system in the rules and make people understand the role of authorized recyclers.

Conclusion and Educational Implication

The awareness of even the term e waste was found to be low and a major initiative is required to make people aware of the e waste. Socio economic conditions are a major determinate of behavior towards e waste. The education programmes need to be customized as per the socio economic status of the target groups with extending the life cycle by donating and repair as an important message to the middle and higher middle class communities. The awareness about proper disposal was also found to very low. Perceived economic value against the price they are getting from recyclers and sentiments attached with the products make the majority of the people to store the e waste at home. This waste will sooner or later will come out as a waste and hence it is important that people are made aware of the proper way to dispose of e-waste as per the rules. The informal waste collection systems working through Kabadiwalla were not found asking for e-waste. There is an opportunity to organize the informal system and link them up with the formal system as envisaged in the e-waste rules for proper handling of e-waste and last mile connectivity. The informal sector can also help in raising awareness on the issue of e-waste. The education programme on e-waste have to address the issue of lack of awareness on proper disposal of e waste, extending the life cysle of the product through donation and repair, communicate the collection centre system established by authorized recyclers and over all encourage people to use the products for a longer period.

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Environmental Impact of Cement Industry on Education in Sagamu, South-West, Nigeria

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Abstract

The study examined environmental impact of cement industry on education of a school cited near a cement factory in Sagamu, South-West of Nigeria. A research instrument was developed, validated and administered to 100 respondents made of 26 teaching and non-teaching staff and 74 students randomly selected from teachers and students who had been in the school between a year and six. Data generated from instrument was analyzed using frequency, percentages and t-test statistics. The study found that pollution affects education in many ways. Noise from blasting of limestone disturb teaching and learning, dust particles frequently settle in classrooms, staff room, laboratories and require cleaning always while coughs among staff and students could be associated with dusts emanating the factory particularly during dry season. There was no significant difference between male and female respondents' knowledge of effects of pollution on education. Respondents who stayed in the school for over four years had better knowledge of the effects than those who stayed less. Students had better knowledge of the effects of pollution on education than their teachers. The paper recommends that the state environmental protection agency, ministries of education, trade and commerce should jointly address environmental pollution in the area.

Key Words: Environmental Impact, Cement Industry, Education

Introduction

Attempt to make life, comfortable for and worthwhile for human beings have resulted in various technological inventions in industrial, agricultural, mining and automobile and their applications. Natural resources exploitation, exploration, mining and processing have caused increase in employment, income as well as different types of environmental damages which include ecological disturbances, destruction of natural flora and funa, pollution of air, water and land, instability of soil and rock masses, landscape degradation and global warming (Gutti, Aji and Magaji, 2012). Cement production is one of the mining industries that belong to this category with some negative effects such as air pollution, noise

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pollution, water pollution and environmental pollution in general among others. Naturally, most people tend to associate air pollution problem with the coming of industrial revolution in the early 60's whereas such problems in one form or another have plagued the human race for centuries. The earliest pollutant noted in the atmosphere was probably of natural origin include ash, fumes, smoke and forest fires, sand and dust from windstorm in arid region, dews during dry season were part of our environment long before human (Otti, Nwajuaku and Ejikeme, 2011). However, studies have found that limestone extraction, processing, packaging and transportation causes environmental pollution both in developed and developing countries but the later control pollution than the former.

Smits study of neurobehavioral effects of environmental pollution found that environmental exposure to industrial solvent use was known to damage the immune system and cause behaviroural problems in animals while its effects on the central nervous system was largely unknown. Mandre, Klos eiko, ats and Tulmets (1999) investigated the impact of long term dust pollution emitted from a cement works on the growth, nutrients content and allocation in. conifers and found that alkaline cement dust (PH12; 3-12.6) and the resulting alkalization of the environment inhibit the height growth of trees, reduce the length of needles and shoots and the biomass of all organs.

In the same vein Kubikora (2004) study of the effect of cement factory air pollution on thermophibus rock grass almond found among others complete disappearance of a number of species, decrease in frequency of other species and increase of frequency of a few of the most resistant species, occupying the free niche, decrease in cover of the community and acceleration of soil erosion, disintegration of the soil profile, enormous accumulation of Ca cations accompanied by decrease of many other mineral elements.

All these point to is that cement factories constitute to environmental pollution (water, air, land, soil, and agricultural outputs). This agrees with Adol-Reza, (2006) who posited that the trend of environmental pollution growth such as global warning as the cause of greenhouse gas emission is among the subjects that modern civilization is challenging. Similarly, Ipav, Dasofunjo and Asaar (2012) study of quality assessment of rain water around a cement factory in Benue state Nigeria found that the water around the cement factory was fit for drinking but with relative high amount of nitrates and contents.

One of the most important impacts of cement manufacturing is the dust generated during storage, milling, packing and transport. Atmospheric mineral dust is an important source of air pollution contains high concentrations of many metals known to have toxic effects not only on plants and animals but also on humans (Branquinho, et al., 2008; Shukla et al., 1990; Hirano et al., 1995 cited by Dubey, 2013). The impact of such anthropogenic emission into the atmosphere and their movement into the biosphere by transformation, reaction and modification is responsible for variety of chronic and acute diseases at the local, regional and global scale (Rawat and Banerjee, 1996 cited by Dubey, 2013). Furthermore, studies have shown adverse respiratory health effects in the people exposed to cement dust, exemplified in increased frequency of respiratory problems (Al-Neaimi *et al.*, 2001).It has also been revealed that people of cement dust zone are badly affected by respiratory problems, gastro intestinal diseases etc. (Adak *et al.*, 2007). Several studies have also demonstrated linkages between cement dust exposure, chronic impairment of lung function and respiratory symptoms in human population. Cement dust irritates the skin (Ikli *et al.*, 2003). Besides, Olaleye and Oluyemi (2010) found flue dusts from cement factory affecting air, water and planktonic irrespective of the season. Ladan (2013) found out that it has been difficult to achieve cooperation for air pollution control in developing countries like Nigeria whose main concern is to provide for the basic needs as food, shelter and employment for her populace. The control measures have not been very effective and fully enforced.

Most studies are on the impact of cement production on environmental pollution such as air, water, farming, agricultural production, health issues and diseases, among others. There is not known study of environmental impact of cement production on education partly because in developed societies schools are not located around cement industries. Though similar practices of not locating schools around cement industries are bound yet there were some schools in existence before discovery of limestone and eventual citing of cement industries close to school. This is the case of a secondary school and West African Portland Cement Organization (WAPCO) cement factory now managed by Lafarge Company, Sagamu, Nigeria. The purpose of the study is to investigate the impact of the environmental pollution on education, with a view to making useful recommendations towards addressing the impact.

Research Question

1. To what extent does pollution from cement factory affect teaching learning process and school environment?

Hypotheses

1. There is no significant difference between male and female knowledge of impact of cement industry on education.
2. There is no significant difference in the mean knowledge of environmental impact of cement industry on education between less and more experienced respondents.
3. There is no significant difference between teachers and students knowledge of the environmental impact of cement industry on education.

Methodology

The research is a survey of students and teachers in a secondary school sharing boundary with the cement company which is perceived to be impacted by the activities of the company.

The research adopted a purposive random sampling technique. 100 respondents made of 26 teaching and non-teaching staff and 74 student respondents made of 26 teaching and non-teaching staff and 74 students drawn across all level of classes were randomly selected from a secondary school close to the factory. The justification for the selection of the subjects lies on the fact that they could give information on the effects of the environmental pollution on education as well as on their general environment.

A research instrument, Environ -mental Impact of Cement on Education Questionnaire (EICEQ) was developed to ascertain the knowledge of students and teachers on the impact of the cement factory on education particularly the learning environment, teaching and learning process, among others.

Draft of the instrument was given to experts in science, education and social sciences to validate and make useful inputs. The final draft of the questionnaire has three sections namely background information, effects of pollution on education and effects of pollution on general environment, trading and farming. Section A sought information on respondents' background information which include gender, occupation (students, teaching, non- teaching), length of time respondent has been living/schooling or working around in the school. Section B elicited information on the effects of pollution on education such as the noise generated from the blasting of limestone, dust littering classrooms, staff rooms, laboratories, related health issues, effects on sports in dry season. Section C dealt with effects of pollution on general environmental, trading arid farming, which included damaging of instructors, discharge of industrial wastes in streams, pollution of plants among others. While section A is open ended statements Sections B and C are multiple-choice type having yes, no, not sure and sometimes as options for respondents to pick from. The questionnaire was administered to the students and teachers in their school and collected back immediately after completion.

Data generated from the completed questionnaires were analyzed using frequency, percentages, and t-test. The t-test was used to analyze the mean knowledge difference between male and female, teachers and students, as well as length of schooling / working while the frequency and percentage were used to summarise the outcomes of the research questions.

Results

Findings on research questions focusing on education are first presented and followed by economic and social. The respondents on education comprised 34 male and 66 female. This number was made of 74 students, 25 teachers and 1 non-teaching staff in school located around the cement factory. These respondents have either been schooling or working in the environment between one and over 5 years and could comment on the impact of the cement factory on learning and general environment.

Effects of Pollution on Education

Question 1:

How does pollution from cement factory affect teaching, learning and recreation process?

Table 1: Responses on effect of cement industry pollution on education.

S.No.	Question	Responses			
1	Noise from frequent blasting of limestone prevents me from hearing my lessons well in the classroom	Yes Freq (%) 28(28)	No Freq (%) 12 (12)	Not sure Freq (%) 1 (1)	Sometimes Freq (%) 59 (59)
2	The dust coming from the cement factory liters the environment including the classrooms	75 (75)	4 (4.0)	2 (2.0)	19 (19.0)
3	Staff quarters & students hotels are often polluted with dust from the cement factory	63(63.0)	13(13.0)	13(13.0)	11(11.0)
4	Dust pollution of classrooms require frequent clearing of the classrooms and laboratories	64(64.0)	5 (5.0)	4 (4.0)	7 (7.0)
5	Occasional coughs among staff and students could be attributed to dust coming from the cement factory	78(78.0)	4 (4.0)	12(12.0)	6 (6.0)
6	Dust pollution stains our uniforms when washed and spread on lines outside to dry	64(64.0)	15(15.0)	16(16.0)	5 (5.0)
7	We find it difficult to organize sports on the field during dry seasons because dust settles on the field	63(63.0)	22(22.0)	9(9.0)	6(6.0)
8	Neither the cement factory nor government makes efforts to control the dust and noise pollution	42(42.0)	34(34.0)	3(3.0)	21(21.0)

It could be observed from table 1 that varied responses were given on the effects of cement pollution on education. 28 respondents said noise from frequent blasting of limestone prevents them from hearing their lessons well in the classroom while 59 said sometimes the blasting does. 12 respondents said the noise does not affect them while 1 was not sure whether it disturbs them from hearing lessons well or not. However the combination of yes and sometimes responses indicate that noise pollution affects teaching and learning.

A combination of 75 yes respondents and 19 sometimes respondents which constitute majority of the respondents indicates that dust generated by the cement factory pollutes the learning environment including the classrooms, laboratories, staff rooms, staff quarters and students' hostels. This requires frequent clearing and time wastage at the expense of learning.

78 yes respondents and 6 sometime respondents respectively were of the view that occasional coughs among staff and students could be attributed to dust emanating from the cement factory. However, 12 respondents were not sure if the problem of coughs was caused by dust pollution from the cement factory. Apart from this, dust pollution also stains students' uniforms and wares as well as staff dresses washed and spread outside to dry up. 64 respondents confirmed this and 5 others who said their clothes were sometimes stained by dust. 63 respondents said the school finds it difficult to organize sports on the sports field during dry seasons because dust settles on the field. 6 others supported this by choosing sometimes which indicates that it sometimes happens.

Forty two (42) respondents said neither the Cement Company nor State or Local Government makes any effort at controlling dust and noise pollution. This indicates that the problem of pollution remains undressed and persists and perhaps no solution at cite yet.

Test of hypotheses

HO_1: There is no significant difference between male and female knowledge of impact of cement industry on education.

Table 2: Knowledge of Environmental Impact of cement industry on Education by gender

Gender	N	X	SD	t	Sig.
Male	34	23.3824	6.3390	.239	-1.185

Table 2 shows that there is no significant difference in the mean knowledge of the environmental impact of cement industry on education between male ad female respondents. Although females had higher mean knowledge of the impact of cement on education than males but the difference is not significant (t = -1.185, df = 98, P>.05). Therefore, **HO_1** is not rejected.

HO_2: There is no significant difference in the mean knowledge of environmental impact of cement industry on education between less and more experienced respondents.

Table 3: Knowledge of Environmental Impact of Cement industry on Education According in Period of stay in the school near cement factory.

Period (in year)	**N**	**%X**	**SD**	**t**	**Sig.**
1-3 4-6	14 86	19.3571 25.2674	5.8390 6.1538	-3.35	.001

Table 3 indicates a significant difference in the mean knowledge of environmental impact of cement industry on education between those respondents who lived in the school environment from 1-3 years and 4 years and above (t=3.355, df = 98, P< .05). Respondents of longer years (4 years and above) had a higher mean knowledge (X=25.2674) than respondents of fewer period (1-3 years) (X = 1.9 3571). Hence, HO_2 is rejected.

HO_3: There is no significant difference between teachers and students knowledge of the environmental impact of cement industry on education.

Table 4: Teachers and students knowledge of environmental impact of cement factory on education

Occupation	**N**	**X**	**SD**	**t**	**sig.**
Teaching Student	26 74	20.0769 25.9730	7. 1606 5.4041	4.382	.000

Table 4 shows that students had higher and significant knowledge of environmental impact of cement factory on education than their teachers (t = 4.382, df = 98, P< .05). Therefore, **HO_3** is rejected.

Discussion of Results

Just as cement factories pollute air, water and land in any part of the world so also it is in Nigeria. Thus, the study found that the pollution emitted by the cement factory impact negatively on education, farming, fishing, and commerce while government and its agencies as well as the factory have no solution to the hazards.

Most of the students and teachers stressed that the noise emanating from limestone blasting affects teaching and learning process. Although some students and teachers did not consider this as a major threat to teaching learning process yet they admitted that the noise dos happen. This indicates that noise pollution has become a constituent to learning environment both staff and students have to contend with.

Apart from noise pollution, both staff and students have to contend with the challenge of dust emanating from the cement factory which liters classrooms, staff rooms and quarters as well as students' hostels. This requires frequent cleaning to make learning environment neat and conducive. This finding agrees with Nwokolo (2014) on effects of cement dust pollution in Ewekoro. In addition, most of the subjects sampled agreed that dust pollution stains their uniforms when washed and spread on lines in the open to dry up. Similarly, the study found that most of these respondents said the school finds it difficult to organize sports on the field in the dry season due to effect of dust particle. This limits sports activities in the school particularly in dry season.

Male respondents' knowledge of environmental impact of cement pollution did not differ significantly from females' even though females had higher mean. This shows that respondents' gender does not influence their knowledge of impact of pollution on education.

However, respondents (staff and students) who had stayed in the school for over four years had better knowledge of the environmental impact than those who stayed less. It suffices to say that the senior students and staff who had stayed for longer period are better aware of the effects of noise and dust pollution in the school. In the same vein, students had better knowledge of the environmental impact of cement factory on education than their teachers. This could be due to the fact that students interact more with school environment than their teachers. They clean their classrooms, hostels, laboratories, toilets and the general environment which could be responsible for better knowledge of the environment than their teachers.

This study did not investigate the extent to which the pollution affect learning outcomes, as this requires deeper investigation and consideration of more variables and comparison with other schools far away from the vicinity of cement factory.

The intervention of the cement company in education is in the area of provision of facilities (more classrooms, computer laboratory, computers, hard wares and soft wares including accessories) and not actually control of the pollution. Thus, occasional coughs among staff and students which could be attributed to dust emanating from the cement factory do not receive health attention from the company whereas in more civilized societies, pollution is controlled to minimize possible air borne health hazards. This is because clean and pure air is very essential for human health and survival.

Conclusion and Recommendations

The study found that environmental pollution from cement factor affect education. Teaching learning process was affected by noise pollution emanating from the factory while the school general environment and classrooms are polluted with dust particles.

In view of these findings, it is recommended that the cement factory should collaborate with the state environmental protection agency and ministry of education in ensuring environmental protection of the school, and it's environ. Where the protection proves difficult, the state ministry of education should consider relocation of the school to a dust free environment. Such relocation should take into cognizance appropriate school mapping. The state ministry of education should legislate to prohibit location of new school cite in the cement area. Furthermore, there is need for the State Environmental Protection Agency to monitor the activities of the cement factory to ensure compliance with environmental policy. In the same vein, the cement factory needs to sponsor environmental education for the school and the community.

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Role of Non Timber Forest Products from the selected sacred groves of Cuddalore and Viluppuram districts of Tamil Nadu

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Abstract

Non-timber forest products (NTFPs) have attracted considerable attention due to the significant role played in benefiting local communities. It is a well-established fact that the local communities nearer to the sacred groves depend on NTFPs as the source of their livelihood. In this context, we present here the role of seventy three plant species which provide the NTFPs from the groves.

Keywords: *Local communities, livelihood, non-timber forest produce.*

Introduction

Non Timber Forest Products (NTFPs) can be defined as all biological materials other than those of exchange value. All over the world, 'NTFP or NWFP are defined as "forest products consisting of goods of biological origin other than wood, derived from forest, other wood land and trees outside forests'. As much as 27 % of the total populations of India i.e 275 million people depend upon NTFPs for at least part of their livelihood (Malhotra & Bhattacharya, 2010; Bhattacharya & Hayat, 2009).

NTFPs have a great potential for creating large scale employment opportunities by means of clear tenured rights, better collection methods and financial support. This helps in reducing poverty and empowering the rural and marginalized sections of the society.

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Most of the sacred groves in the state do not allow NTFPs and wood/ timber to be harvested from the groves. However, there are a few exceptions. It is necessary to quantify the NTFPs in order to understand the value of the goods (Malhotra and Barik, 2012).

Methodology

Data on the NTFPs were collected in the sacred groves mainly through informal interviews with the local communities of the respective villages in the Cuddalore and Villupuram districts who are involved in the collection of the NTFPs and by accompanying them to the sacred groves when going for collection. The study sites depended on tropical dry deciduous forests and dry deciduous forests. The study sites are G.Ariyur (**G.Ar.)**, Kallakurichi (**KI)**, Melakurichi (**MI)**, Palrampattu (**PU)**, Sadaikatti (**SI)**, Sirupakkam (**SM)**, Melkalpoondi (**MKI),** Ulagankkathan (**UN)**, and Vadakkanandal (**VL).**

Results

A total of 73 plant species belonging to 62 genera and 35 families were documented from the nine sacred groves. The plant species include trees (34 species), herbs (20 species), climbers (13 species) and shrubs (6 species) and the species belonging to the dominant families such as Apocynaceae (6 sp.), Caesalpiniaceae (5 sp.) and Malvaceae (5 sp.) followed by Mimosaceae (4 sp.), Rutaceae (4 sp.), Capparaceae (3 sp.), Fabaceae (3 sp.), Meliaceae (3 sp.), Moringaceae (3 sp.), Myrtaceae (3 sp.), Acanthaceae (2 sp.), Amaranthaceae (2 sp.), Arecaceae (2 sp.), Aristolochiaceae (2 sp.), Asclepiadaceae (2 sp.), Asparagaceae (2 sp.), Cucurbitaceae (2 sp.), Lamiaceae (2 sp.), Moraceae (2 sp.), Sapindaceae (2 sp.), Sapotaceae (2 sp.), Anacardiaceae (1 sp.), Asphodelaceae (1 sp.), Asteraceae (1 sp.), Ebenaceae (1sp.), Euphorbiaceae (1sp.), Loganiacea (1 sp.), Menispermaceae (1 sp.), Nyctaginaceae (1 sp.), Pedaliaceae (1 sp.), Rhamnaceae (1 sp.), Rubiace (1 sp.), Solanaceae (1 sp.), Violaceae (1 sp.),Vitaceae (1 sp.) and Zygophyllaceae (1 sp.).

We have interviewed the local people, about the collection of NTFPs from 61 (79%) of men and 16(21%) of women.

Non timber forest productions (NTFPs) have been collected from 9 sacred groves. The dominant groves are Palrampattu grove (13 sp.), followed by Kallakurichi grove (12 sp.), Ulagankathan grove (12 sp.), Melkalpoondi (11 sp.), Melakurichi grove (10 sp.), Vadakanandal grove (10 sp.), Sirupakkam grove (7 sp.) G.Ariyur grove (4 sp.) and Sadakatti grove (3 sp.).

Several NTFPs were found to have been extracted in the different study sites of Cuddalore and Viluppuram districts (Table-1). Seventy three major categories of non-timber forest products which were recorded during survey in the present investigation which includes different forms of tannin, bark, fruits, leaf, flowers, seeds and whole plants.

Table 1 – Non Timber Forest Products collected from the groves by the local communities

S.No.	Botanical Name	Raw material/ Per kg	Collected parts	Family	NTFPs Collected groves	Month of collection
1.	*Abrus precatorius* L.	45	Seed	Fabaceae	UN	January - March
2.	*Abutilon indicum* (L.) Sweet	20	Leaf	Malvaceae	VL	September - December
3.	*Acacia nilotica* (L.) Delile	30	Bark	Mimosaceae	PU	April - June
4.	*Acacia nilotica* (L.) Delile	45	Tannin	Mimosaceae	PU	January - March
5.	*Acalypha indica* L.	27	Whole plant	Euphorbia -ceae	VL	September - December
6.	*Achyranthes aspera* L.	30	Whole plant	Amarantha -ceae	MKI	September - December
7.	*Aegle marmelos* (L.) Correa	16	Leaf	Rutaceae	G.Ar	Throughout the year
8.	*Aerva lanata* (L.) Juss. ex Schult.	35	Whole plant	Amarantha -ceae	UN	September - April
9.	*Albizia lebbeck* (L.) Benth.	27	Pod	Mimosaceae	PU	December- January
10.	*Aloe vera* (L.) Burm.f.	40	Whole plant	Asphodela -ceae	SM	June – October
11.	*Andrographis paniculata* (Burm. fil.) Nees	58	Whole plant	Acanthaceae	KI	March - December
12.	*Asparagus racemosus* Willd.	74	Tuber	Asparaga -ceae	SM	July – August
13.	*Atalantia monophylla* (L.) Corr. Serr.	22	Fruit	Rutaceae	MI	December - March
14.	*Azadirachta indica* A. Juss.	200	Flower	Meliaceae	KI & MKI	February - September
15.	*Azadirachta indica* A. Juss.	15	Bark	Meliaceae	KI	April – June
16.	*Azadirachta indica* A. Juss.	20	Seed	Meliaceae	SM	October - December
17.	*Blepharis maderaspatensis* (L.) Heyne ex Roth	32	Whole plant	Acanthaceae	UN	November- February
18.	*Boerhaavia diffusa* L.	45	Whole plant	Nyctagina -ceae	VL	August- October
19.	*Borassus flabellifer* L.	60	Fruit	Arecaceae	MKI	March-April & May
20.	*Calotropis gigantea* (L.) W. T. Aiton	20	Stem	Asclepiada -ceae	VL	Throughout the year

S.No.	Botanical Name	Raw material/ Per kg	Collected parts	Family	NTFPs Collected groves	Month of collection
21.	*Capparis zeylanica* L.	42	Leaf	Capparaceae	MKI	Throughout the year
22.	*Cardiospermum halicacabum* L.	60	Whole plant	Sapindaceae	MI , PU	July-February
23.	*Cassia fistula* L.	18	Fruit	Caesalpinia -ceae	KI	April-June
24.	*Cissus quadrangularis* L.	20	Stem	Vitaceae	MKI	June-January
25.	*Citrus aurantiifolia* (Christm.) Swingle	10	Fruit	Rutaceae	PU	November-January
26.	*Cleome gynandra* L	35	Whole plant	Capparaceae	SM	January - February
27.	*Cleome viscosa* L.	26	Whole plant	Capparaceae	SM	January - February
28.	*Coccinia grandis* (L.) Voigt	25	Fruit	Cucurbita -ceae	MI	December-April
29.	*Diospyros montana* Roxb.	35	Seed	Ebenaceae	MI	February-April
30.	*Ficus benghalensis* L.	40	Fruit	Moraceae	KI	Throughout the year
31.	*Ficus benghalensis* L.	10	Bark	Moraceae	KI	Throughout the year
32.	*Gymnema sylvestre* (Retz.) Schult.	35	Whole plant	Apocyna -ceae	UN	July-January
33.	*Hemidesmus indicus* (L.) R. Br.	74	Whole plant	Asclepiada -ceae	VL	Throughout the year
34.	*Hybanthus enneaspermus (l.) F. Muell.*	100	Whole plant	Violaceae	UN	Throughout the year
35.	*Lannea coromandelica* (Houtt.) Merr.	15	Leaf	Anacardia -ceae	KI	June – January
36.	*Leucas aspera* (Willd.) Link	22	Whole plant	Lamiaceae	PU	September-January
37.	*Madhuca longifolia* (J.Koenig ex L.) J.F.Macbr.	24	Seed	Sapotaceae	MKI	October-November
38.	*Madhuca longifolia* (J.Koenig ex L.) J.F.Macbr.	35	Flower	Sapotaceae	MKI	March-April
39.	*Morinda pubescens* Sm.	50	Fruit	Rubiaceae	MKI	March-June
40.	*Moringa oleifera* Lam.	25	Leaf	Moringaceae	G.Ar	Throughout the year
41.	*Moringa oleifera* Lam.	45	Flower	Moringaceae	G.Ar	January – April
42.	*Moringa oleifera* Lam.	28	Tannin	Moringaceae	G.Ar	Throughout the year

S.No.	Botanical Name	Raw material/ Per kg	Collected parts	Family	NTFPs Collected groves	Month of collection
43.	*Mukia maderaspatana* (L.) M. Roem.	24	Whole plant	Cucurbita -ceae	M.KI	Throughout the year
44.	*Ocimum sanctum* L.	30	Whole plant	Lamiaceae	UN	Throughout the year
45.	*Pavonia zeylanica* (L.) Cav.	8	Leaf	Malvaceae	UN	Throughout the year
46.	*Pedalium murex* L.	40	Whole plant	Pedaliaceae	UN	Throughout the year
47.	*Pergularia daemia* (Forsskal) Chiov.	26	Whole plant	Apocynaceae	PU	Throughout the year
48.	*Phoenix sylvestris* (L.) Roxb.	40	Fruit	Arecaceae	SI	September—October
49.	*Pithecellobium dulce* (Roxb.) Benth.	80	Fruit	Mimosaceae	KI	February-March
50.	*Pongamia pinnata* (L.) Pierre	34	Seed	Fabaceae	KI	April-December
51.	*Sansevieria roxburghiana* Schult. & Schult.f.	20	Whole plant	Asparaga -ceae	SM	Throughout the year
52.	*Sapindus emarginata* Vahl	15	Seed	Sapindaceae	MKI	August-December.
53.	*Secamone emetica* (Retz.) Schult.	20	Whole plant	Apocyna -ceae	VL	May-November
54.	*Senna auriculata* (L.) Roxb.	45	Flower	Caesalpinia -ceae	PU	January – May
55.	*Senna auriculata* (L.) Roxb.	35	Seed	Caesalpinia -ceae	PU	Apirl – June
56.	*Senna auriculata* (L.) Roxb.	48	Tannin	Caesalpinia -ceae	PU	February – July
57.	*Sida acuta* Burm. f.	10	Whole plant	Malvaceae	UN	Throughout the year
58.	*Sida cordifolia* L.	16	Whole plant	Malvaceae	UN	Throughout the year
59.	*Solanum trilobatum* L.	65	Whole plant	Solanaceae	VL	January-August
60.	*Strychnos nux-vomica* L.	42	Seed	Loganiaceae	KI	March-December
61.	*Syzygium cumini* (L.) Skeels	20	Seed	Myrtaceae	VL	June—August
62.	*Syzygium cumini* (L.) Skeels	32	Tennin	Myrtaceae	VL	January—March
63.	*Syzygium cumini* (L.) Skeels	26	Bark	Myrtaceae	VL	Throughout the year
64.	*Tamarindus indica* L.	80	Fruit	Caesalpinia -ceae	SM &MKI	February—April
65.	*Tephrosia purpurea* (L.) Pers.	10	Whole plant	Fabaceae	KI	October-December

S.No.	Botanical Name	Raw material/	Collected parts	Family	NTFPs Collected	Month of
66.	*Thespesia populnea* (L.) Sol. ex Correa	12	Flower	Malvaceae	PU	March-June
67.	*Tinospora cordifolia* (Willd.) Hook. f. & Thomson	42	Leaf	Menisperma -ceae	SI	January-June
68.	*Toddalia asiatica* (L.) Lam.	14	Whole plant	Rutaceae	MI	January - June
69.	*Tribulus terrestris* L.	36	Whole plant	Zygophylla -ceae	UN	Throughout the year
70.	*Vernonia cinerea* (L.) Less.	8	Whole plant	Asteraceae	KI	Throughout the year
71.	*Wattakaka volubilis* (L. fil.) Stapf.	20	Whole plant	Apocynaceae	SI	July-November
72.	*Wrightia tinctoria* R.Br.	60	Bark	Apocynaceae	PU	Throughout the year
73.	*Ziziphus mauritiana* Lam.	30	Fruit	Rhamnaceae	UN	December-March

G.Ariyur (**G.Ar.**), Kallakurichi (**KI**), Melakurichi (**MI**), Palrampattu (**PU**), Sadaikatti (**SI**), Sirupakkam (**SM**), Ulagankkathan (**UN**), Melkalpoondi (**MKI**) and Vadakkanandal (**VL**).

Conclusion

Of late, there are significant changes which have taken place in the NTFP segment and they are widespread forest degradation which has led to a decline in NTFP resources. Similarly, increasing commercialization of the rural economy has resulted in the increased penetration of the market economy into all aspects of rural life. The collections of NTFP conferred significant economic benefits to the local communities in terms of their basic needs and livelihood earnings. These are mostly seasonal in nature.

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