"TOWARDS ZERO GARBAGE"

TAMILNADU POLLUTION CONTROL BOARD
76, MOUNT SALAI, GUINDY, CHENNAI – 600 032

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WASTE NOT THE WASTE

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Introduction:

We are now in the beginning of the 21st century. The situation is quite grim with regard to continuous availability of fossil fuels. These fossil fuels might not last more than four decades from now. Man has to necessarily turn his attention more towards renewable forms of energy to meet his energy needs. He has already found technologies to tap energy from the sun, the wind and the hydrogen (fuel cells). Yet another source that remains totally unexploited is waste energy. Waste too is an excellent resource for energy. Waste is a misplaced resource and an unrecognised wealth.

Municipalities and Solid Waste:

India is a country rich in natural resources and being an agrarian economy we generate a lot of organic waste that is **compostible** (85%) and not **combustible.** This rich biomass can be converted into bio-energy in the form of rich organic manure that can be utilised for meeting the energy needs of our crops. Even animal waste is known for producing bio-gas that meets the domestic and farming needs of Indian rural households.

Many of India's cities face the problems of solid waste due to increase in population and consumerism. The quantity of waste has multiplied today and we need to manage it. Municipalities are perplexed, not knowing what to do with waste.

They need :

- Manpower
- Trucks
- Equipment
- Fuel
- Landfill

to manage waste.

These cost quite heavily and the revenue is insufficient to meet the ever-growing expenditure towards solid waste management. Yet, the solid waste management of today suffers from the following:

1. The municipal staff lack motivation due to the complexities of their work
2. The trucks are old and inefficient
3. The equipments are worn out
4. The landfills are nearly full

Of all the problems, the serious one is pollution of landfills and exhaustion of landfill sites. In India, we don't have even one sanitary landfill.

1. When municipal trucks transport the garbage they cause air pollution through their exhaust.
2. The garbage dumped at the landfill causes air pollution, sub soil pollution and ground water pollution.

Unable to find a place to dump garbage, the local bodies find it convenient to offload the trash in all the water bodies like ponds, lakes, tanks and riverbeds etc. which are serving as source of drinking water. We lose both ways.

The accumulated garbage causes a variety of problems including becoming a health hazard. If there is a change in the mental attitude of all those concerned, the whole scenario will change.

Why Waste Waste? ($W^{3)}$

How to convert Waste into Wealth?

The important principles in 100% efficient total solid waste management are as follows:

1. Source Separation **2.** Home Composting/ Community Composting **3.** Community Trash Bank **4.** Zero Waste Home/ Zero Waste Neighbourhoods **5.** Home Farming and **6.** Home Exnora

1. Source Separation:

"Source Separation" is the first and most important activity in every home for realising environment friendly homes. The way it works is very simple. In every home, two baskets should be bought, one green and another red in colour. The **green** basket is meant for kitchen waste, which is organic in nature, called wet waste and is designated by Exnora as **Compostable (compostible) waste**. The **red** basket is meant for man-made waste such as paper, plastic, metal and glass, which is inorganic in nature, called dry waste, and designated by Exnora as **recyclable waste.** Printed signs can be pasted. The colours have significance. First, even people who cannot read, can go by colour. Second is the relation of the nature of waste to the colour. The kitchen waste is deposited in the green basket, as its origin is green. Further, the waste in green basket will be converted as a bio-manure and will help greening activities including horticulture and farming. The origin is green. The end is green. Naturally the basket colour is green. The red colour signifies danger. Improper disposal of plastics is dangerous. Man-made waste also has its origin from natural resources. If we exhaust them, we will have problems. Discarding waste is a **commission**. Non-recycling is an **omission,** as an excellent resource is wasted. **"Waste not the Waste"** is Exnora's slogan. If we recycle it, the exploitation of natural resources is reduced and we help conservation.

2. Home Composting / Community Composting:

Both are needed. The focus should be on **Home Composting**. But every home in a street will not join due to so many reasons. Then **Community Composting** should also be carried out at the colony or street level, to supplement / complement Home Composting, to take care of those who do not do composting in their home. This is the best method to ensure no domestic trash goes to landfill. (This will be saving the "**Landfill space**" and **"Save landfill" too.)**

3. Exnora's Trash Bank (in community and schools)

- Citizens who do source segregation will compost organic waste in their home
- The recyclable waste can be taken to a community trash bank functioning of which is explained here. Four large bins in different colours is kept in the street where the citizens transfer their household recyclable waste in the exact bin. Paper waste will be deposited in the white bin, plastic waste in the red bin, glass waste (only reusable bottles) in yellow bin and other recyclables wastes (eg. metal) in blue bin.
- The waste will be sold to scrap shop or waste dealers. They will come, pay and take. The waste will fetch sizable money for the community
- There will be two more bins green in colour in which organic waste (from those homes where home composting is not practiced) deposited for composting. All the six bins can have a simple small cement sheet roof. The spot can be designated as "Zero Waste Centre". The problem of trash is solved and landfill is saved.

3. Zero Waste Home

Organic waste can be composted in different ways, eg. vermi composting through pit or compost box, aerobic composting through compost bin, etc. If you combine garden waste with kitchen waste, it is good for composting especially since it will create pores for air circulation. The recylcable waste in the red basket can be off loaded into a sack (jute bag or plastic woven sack bag). Bag is recommended because its capacity is more. Unlike organic waste, the recyclable waste can be retained for a few days. The recyclable waste can be sold as scrap when the bag is full. It is still better to do this collectively for the whole colony by forming Street or Colony Exnora. In such cases, the buyer will come to buy. Or the recyclable waste can be gifted to rag pickers, creating livelihood for the rag pickers. The important advantage of Zero Garbage is that cattle don't invade the roads. There is also no bacteria generation from discarded organic waste. A lot of money is saved by local body towards purchase of trucks and fuel and payment of salary to workers. There is no garbage pollution by

Municipal trucks or air pollution from the exhaust of the trucks. There is saving of wet land by non-dumping garbage. There is no air pollution, soil pollution, ground water pollution etc. at the landfill.

4. Home Farming:

The entire empty space around every house as well as the terrace can be converted as Farm land. The containers considered waste can be used for Home Farming. This will also be called "Terrace Farming", when the terrace is used and sky farming when sky space is used. (For the innovations made, appropriate new words are also coined.) **Your home** book published by EXNORA gives the know how of various types of composting and home farming which can be practiced both at home and community level.

5. Home Exnora:

Home Exnora is the minutest micro-organisation in every home. All the family members and servants are the members of each Home Exnora. Exnora International promotes Home Exnora through Exnora Innovators' Club in every town. Exnora goes to schools and creates environmental awareness and teaches Pro-Environment Action Programmes to be carried out by the students in their home with the help and support of other members of family. The Exnora programme covers the following:

The important activities that are recommended in each home to carried out by the members of Home Exnora (family members) are:

a. *Home Hygiene (H2)*
b. *Vehicle Pollution Control (Noise & Smoke)*
c. *Waste Minimisation*
d. *Home Source Segregation & Home Zero Garbage*
e. *Tree Planting*
f. *Home Farming*
g. *Home P3 by M3*
h. *Home Rain Harvesting*
i. *Clean House-Front*
j. *Green House-Front*
k. *Prevention of Mosquito Breeding*
l. *Noise Pollution Prevention*

m. Home Energy Conservation
n. Home Water Conservation

Plastics Pollution Prevention (P3) by Minimum use, Maximum reuse, Mandatory Recycling / Safe Disposal (M3) of plastics.

Any municipality by introducing this concept in their town can effortlessly and easily solve all their problems of insanitation including solid waste because half the homes have school going children. When this concept is introduced as a school project the children are bound to carry on the same in their home. Naturally the Municipality will be solved the botheration to that extent. The other homes will be approached by the street level and colony level meetings. Of course the message will spread by itself.

Decentralised Two Tier Solid Waste Management:

The programme of two tier, Home Composting and Community Composting is the total cure to the vexing problem of Solid Waste. It is not only "Zero Solid Waste" but also "Zero Transport", "Zero Cost", "Zero Expenditure", "Zero Complaints", "Zero Pollution", "Zero Budget" for Municipality. (A lot of income will be there to the Community / Municipality.) It will save landfill space.

Conclusion:

The above ideas are already tested in several hundreds of colonies in different parts of the country and have proved to be a great success. By enlisting people's participation, Zero Waste Colonies have become a reality. The latest Home Exnora concept is a major breakthrough in Exnora's twelve years history. Any municipality can try and within two years the volume of garbage can be reduced by 50% and within three years from actual commencement the town covered by municipality can become a Zero Waste Town. But the beginning should be made now.

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BIOCOMPOSTING OF ORGANIC WASTES

BIO-COMPOSTNG OF ORGANIC WASTES

Organic wastes can be composted either anaerobically or aerobically. Anaerobic composting used to be prevalent in villages where the organic residues used to be put in pits and closed. The composted endproduct called compost was collected after six months.

Amongst aerobic composting the most popular has been the NADEP composting. Biodung composting though predominantly aerobic may have anaerobic pockets. Vermicomposting is another form of aerobic composting.

Earthworms form a major component of the soil system and these organisms have been ploughing the land for millions of years assisting in the recycling of organic nutrients for the efficient growth of plants.

RECYCLING OF WASTES THROUGH VERMITECH

Recycling of wastes through Vermitech reduces the problem of non-utilisation of agrowastes. Nutrients present in vermicompost are readily available and the increase in earthworm populations on application of vermicompost and mulching lead to the easy transfer of nutrients to the plants providing synchrony in ecosystems. The availability of nutrients in soils tilled by earthworms is definetely more due to the formation of burrows called drilospheres. Vermicompost therefore leaves no doubt on its potential for good yields, the yield however depends on the management practices followed by the farmer.

Natural or organic farming wherein farmyard manure is used, is preferable today to chemical fertilisers used in hightech green revolution. Agricultural lands are more sustainably maintained for lasting and productive use by natural farming. Vermitech i.e., introducing earthworms into soil or to form vermicompost is the most natural, ancient and perhaps the best among all sustainable agricultural practices.

Compostable urban as well as agrowastes can be converted into compost. Vermicomposting is a more sustainable technique for solid waste disposal, compared to the conventional methods like landfilling, incineration, biogas production and composting by the efflux of time. Nutrients in earthworm castings are predigested and readily soluble in water for uptake by plants.

VERMICOMPOST

Every type of soil has different species of earthworms and hence choosing a local or native species of earthworm for the local soil and for vermicomposting is the first important step. There is no need to import or buy earthworms from elsewhere. The local species of earthworms which are good to be used in vermitech are the surface dwellers like Perionyx excavatus and the sub-surface dwellers like Lampito mauritii.

The Compost Pit:

Compost pit of any convenient dimension can be dug in the backyard or garden or in a field. The most convenient pit of easily manageable size is 2m x 1m x 0.75m.

(A tank may be constructed with brick and mortar with proper water outlets, or a plastic crate (60cm x 30 cm x 30 cm) with holes drilled at the bottom or empty wooden crates (dealwood boxes) or well rings of 75 cm dia and 30 to 45 cm height can also be used with slight modifications in the thickness of layers used.)

The Vermibed:

Vermibed is the actual layer of good loamy soil to be placed at the bottom of the pit, about 15 to 20 cms thick above a thin layer (5 cms) of broken bricks and sand. Earthworms are introduced in the loamy soil, which the worms will inhabit as their home.

Introduction of earthworms:

About 100 earthworms may be introduced as an optimum inoculating density into a compost pit of about 2m x 1m x 0.75m, with a vermibed of about 15 to 20 cms thick. The vermibed should always be kept moist, but should never be flooded.

Organic layering:

Handfull-lumps of fresh cattle dung are then placed at random over the vermibed. The compost pit is then layered to about 5cm with dry leaves or preferably hay. For the next 30 days the pit is kept moist by watering it whenever necessary. The pit may then be covered with coconut or palmyrah leaves to discourage birds.

Wet layering:

After the first 30 days, as above, wet organic wastes of animal and /or plant origin from the kitchen or hotel or hostel or farm can be spread over it to a thickness of about 5 cm. This can be repeated twice a week. All these organic wastes can be turned over or mixed periodically with a pickaxe or a spade. Care should be taken not to disturb the vermibed in which the worms live. Keep adding garbage till the compost pit is nearly full. Continue to keep the pit moist for another 30 – 45 days, turning over the material in the pit with care.

Harvesting:

When the compost is ready for harvesting, moistening of the pit should be suspended for 3-4 days, so as to allow the compost to dry. This also facilitates the worms to go to the deeper layers and eventually into the vermibed. Dig out the compost without disturbing the vermibed. Spread the compost in the open to airdry, sieve through a 2.5mm sieve and pack for use.

For bulk material or material like market wastes and agrowastes, it is desirable to first do biodung composting before vermicomposting.

This enhances the temperature of the composting material under biodung composting to 70 degrees Celsius. Such high temperatures enable elimination of most of pests and parasites as well as kill any viable seeds in the input material. This is followed by vermicomposting.

The general recommended dosage of vermicompost to soil application is given below. These may however change based on requirements like any other fertilizer:

- 100 gms of vermicompost for a pot containing 8 to 10 kg soil
- 1-10 kg of vermicompost per tree, depending on size of tree
- 2000 kg of vermicompost per acre of land
- Regular watering and mulching of the land is important
- No chemicals should be sprayed over the compost pit
- Foliar sprays are recommended, only if necessary, for plants

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VERMITECH

(Vermicompost and Vermiwash)

VERMITECH

The technology to use surface and sub-surface local varieties of earthworms in composting and soil management is called ***VERMITECH.*** There are more than 500 species of earthworms in India. Functionally speaking, based on ecological strategies, earthworms can generally be classified into three categories. They are:

1. **Epigeics:**These are the surface dwellers feeding predominantly on litter and excreta of other organisms. These are largely used in the composting process.
   Examples: Perionyx excavatus, Eisenia foetida, Eudrilus eugeniae.

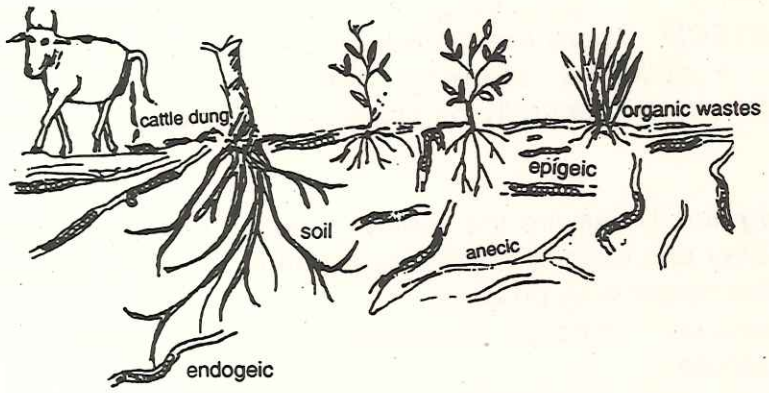
2. **Anecics:**These are the subsurface dwellers. They predominantly create vertical burrows. They feed on litter, animal excreta and organically rich soil. They are both good for composting and soil improvement, especially soil eration.
   Example: Lampito mauritii

3. **Endogeics :** These predominantly make horizontal burrows and feed on organically rich soil. They are soil formers.
   Example: Octochaetona thurstoni

Regular inputs of feed materials for the earthworms can be in the form of agrowastes and kitchenwastes, and nitrogen rich materials like cattledung, goat manure and pig manure. Poultry manure should however be handled carefully due to the presence of toxic components.

Composting should be done by using what is available locally. A farm can use agrowaste, a vegetable dealer can use spoilt vegetables, a dairy farm can use cattle dung, a housewife or a restaurant can use kitchen waste and so on. In the absence of proper nitrogen inputs in the form of cattledung or other nitrogeneous supplements, leaves from trees like drumstick

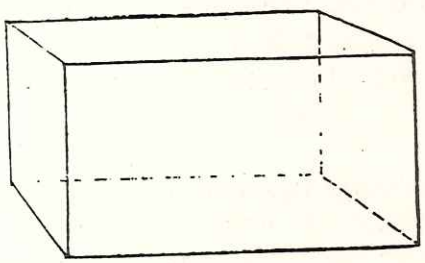
(Moringa oleifera) and subabul (Leucaena leucocephala) can be added.



By processing these wastes into organic fertilizers we also get rid of organic solid wastes. Vermicomposting therefore is also solid waste management, where organic solid wastes are considered as resources.

VERMICOMPOST

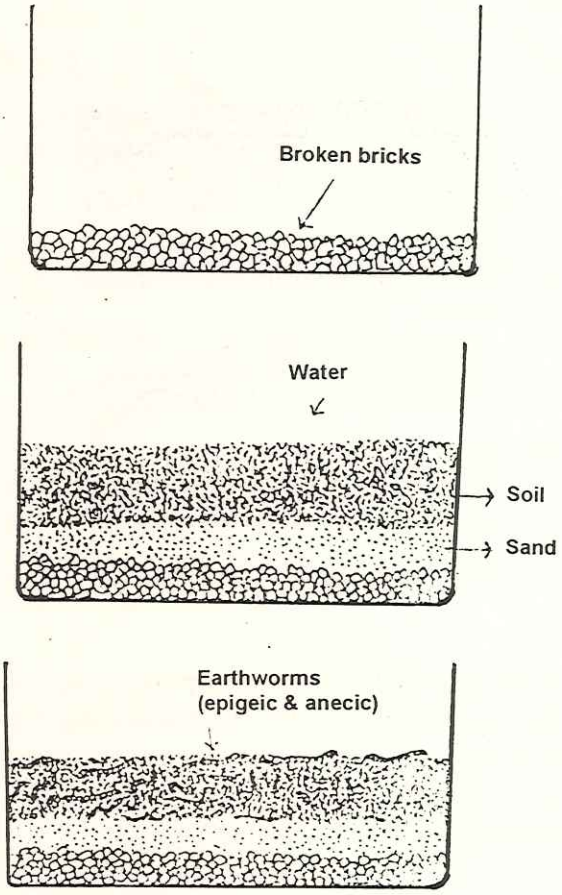
Composting can be done either in pits or concrete tanks or well rings or in wooden or plastic crates appropriate to a given situation.



pit or crate

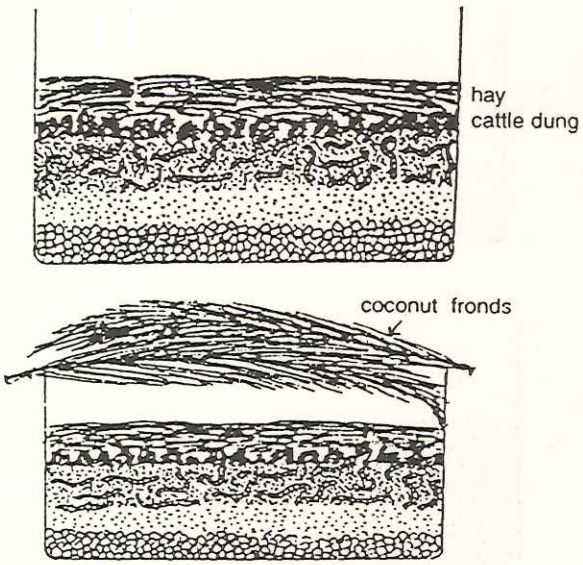
It is preferable to select a composting site and a shade, in the upland or elevated level, to prevent water stagnation in pits during

rains. Regions with rainfall may better avoid pits. In places where rainfall is confined only to few days in a year, flooding of pits by rain does not cause much harm as local varieties of earthworms return when conditions turn normal.



Vermicomposting is set up by first placing a basal layer of vermibed comprising of broken bricks or pebbles (3-4 cms) followed by a

layer of coarse sand to a total thickness of 6-7 cms to ensure proper drainage. This is followed by a 15 cm moist layer of loamy soil. Into this soil are inoculated about 100 locally collected earthworms (about 50 surface and 50 subsurface varieties). Small lumps of cattledung (fresh or dry) are then scattered over the soil and covered with a 10 cm layer of hay.

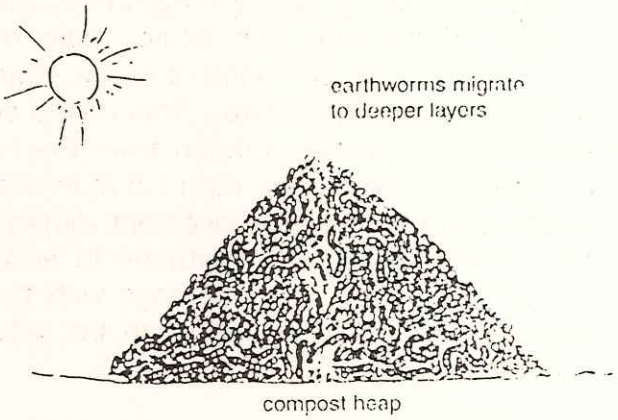


Water is sprayed till the entire set-up is moist but not wet. Less water kills the worms and too much chases them away. The unit is kept covered with broad leaves like those of coconut or palmyrah. Old jute bags can also be used for covering but plastic covering should be avoided as it traps heat and gases.

Watering the unit is continued and the unit is monitored for 30 days. The appearance of juvenile (baby) earthworms by this time is a healthy sign.

Organic refuse is added from the thirty-first day as a spread on the bed after removing the fronds. The spread should not exceed 5 cms in thickness at each application.

Though addition of this amount of matter can be done everyday, it is advisable for a beginner to spread only twice a week, watering to requirement. After a few applications, the refuse is turned over without disturbing the bed. The day enough refuse has been added into the unit, just keep watering and turning over, and 45 days later the compost is ready for harvest.



compost heap

As the organic refuse changes into a soft, spongy, sweet smelling, dark brown compost stop adding water (42nd day). This moves the worms into the vermibed. Harvest the compost and place the harvested compost in the form of a cone on solid ground in bright sunlight. This will facilitate whatever worms present in the compost to move to the lower layers. Spread the compost pile after about 24 to 36 hours, recover the worms from the lower layers of the

compost through a 2 mm or 2.5 mm sieve, if necessary, and pack in polythene bags to retain moisture.

COMPOSTING IN BULK

When large quantities of wastes are available like agrowastes and municipal solid wastes, then it is advisable to first predigest the waste before transferring it to vermicomposting units.

For predigesting either you can apply dilute cattledung slurry on the garbage, mix it well, moisten it to 50 to 60 percent with water and leave it for fifteen to twenty days on ground as a heap or a windrow with frequent turnovers, adding water if required. The temperature of these heaps raises to about 60^0C. This is advantageous in two ways. This can destroy the pathogens as well as destroy any live seeds of weeds in the waste.

An alternative to this is biodung composting which recommends placing layer by layer of garbage with dilute cattle dung slurry sprayed in between layers. The presence of green material in the form of leaves enhances the temperature. This unit is set up on a stack of poles and twigs to permit aeration from the base. The heap is not recommended to be greater than 1.5 m in width and 1.5 m in height. Length can be of any convenient dimension. The entire unit can be covered with black polythene to accelerate the process of decomposition. After 20 to 25 days with two or three turnings, the material looks like dung and can be, after cooling, introduced for vermicomposting.

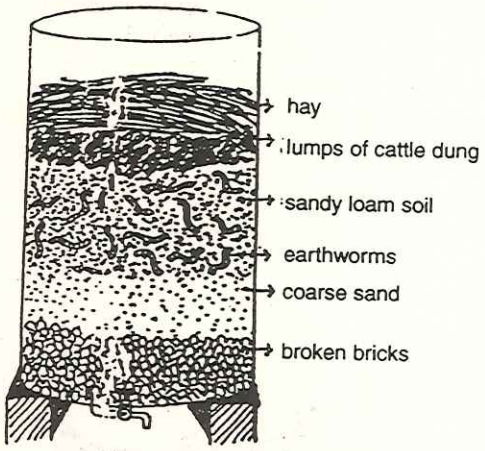
Recommended dose: 100 gm per potted plant, 1 – 10 kg for trees depending on age of tree and 2000 – 3000 kgs/acre for crops like paddy.

VERMIWASH

Foliar sprays are a part of plant growing practices and several expensive packages of foliar sprays are today available in the market.

Worm worked soils have burrows formed by the worms which aid in the passage of water washing the nutrients from these burrows to the roots to be transported to the shoot. This principle is applied in the preparation of VERMIWASH. The vermiwash therefore is a good foliar spray.

inner layers of vermiwash unit

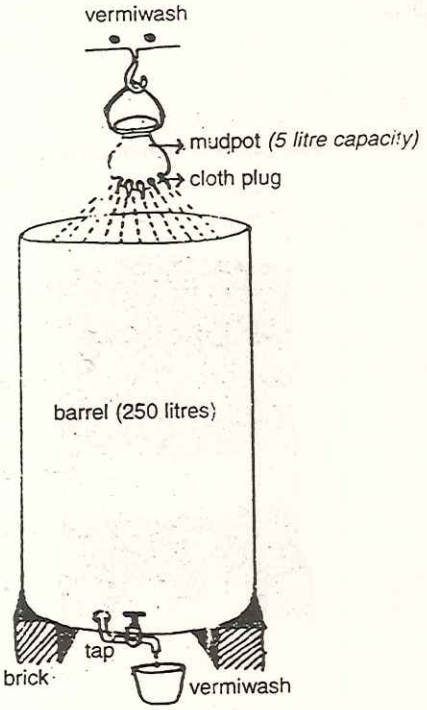


SETTING UP OF A VERMIWASH UNIT:

Vermiwash units can be set up either in barrels or buckets or in mud pots.

An empty barrel with one open side is taken. On the other side, a hole is made to accommodate the vertical limb of a 'T' jointed tube in a way that about half to one inch of the tube projects into the barrel. To one end of the horizontal limb is attached a tap. The other end is kept closed. This is opened to clean the 'T' tube. The barrel is mounted on a few bricks to prevent damage to the tap as well as to facilitate collection of vermiwash.

Keeping the tap open, a 25 cm layer broken bricks or pebbles is placed. This is then followed by a 25 cm layer of coarse sand. Water is then made to flow through these layers to enable the settling of the basic filter unit. On top of this is placed a 30 to 45 cm layer of good loamy soil.



It is moistened and into this are introducted about 50 numbers each of the local varieties of surface and sub-surface earthworms. Cattle-dung pats and hay are then placed on top of the soil layer and gently moistened. The tap is then closed after excess water is drained. The unit is moistened every day for about 10 to 15 days. The tap is kept open for sometime to drain excess water from the unit every time the unit is moistened. During these 10 to 15 days, the earthworms multiply in number, as well as produce burrows in the soil.

Once the unit is ready, say the 16th day, the tap is closed and on top of the unit, a container is suspended (metal or mudpot) perforated at the base as a sprinkler and into it is poured 5 litres of water (this volume will be less if a bucket or mudpot is used). Water is allowed to gradually sprinkle on the unit. It percolates

through the compost and the burrows and gets collected at the base. The tap of the unit is opened the next day and the vermiwash is collected. The tap is then closed and the suspended pot is refilled with water to be collected again as vermiwash the following day. Dung pats and hay may be replaced periodically. The entire set-up can be emptied and reset with fresh soil once a year.

If a mudpot is used to set up the vermiwash unit, then a hole may be made near the base at the side of the pot and may be blocked by a thick cloth plug which can serve as a tap.

Vermiwash is sprayed on plants as a foliar spray. It has proved very effective on vegetable plants like okra, tomato, beans eggplants, lawns, golf courses and orchids If need be, vermiwash may be diluted with water as a spray; or maybe diluted in 10 percent cows urine as an organic pesticide. More research on the potential of vermicompost and vermiwash is in progress at our unit. Readers who have tried the production and application of vermicompost and vermiwash may kindly give their feedback on their potential to Dr. Sultan Ismail.

For detailed information on Earthworms:

Please read:

Vermicology : The Biology of Earthworms by Sultan Ismail, Orient Longman. Chennai.

Please see on video:

Vermitech: Harnessing earthworms for the benefit of mankind. In Tamil, English and Hindi, Audio Visual Aids, Chennai

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WASTE INCINERATION AND DIOXINS

Introduction

The generation of municipal solid wastes, in general, and the plastic wastes in particular is increasing uncontrollably all over the world. This has caused serious concern due to the environmental and health effects of their disposal. There is an urgent need for a national waste management strategy, based on a four-stage decision procedure:

- **1st - Wherever possible, avoid creating wastes.**
- **2nd - Where wastes are unavoidable, recycle them if possible.**
- **3rd - Where wastes cannot be recycled in the form of materials, recover energy from them.**
- **4th - When the foregoing options have been exhausted, utilise the best practicable environmental option to dispose of waste.**

With poor record of waste reduction and recycle, the third option, energy recovery through incineration is often emphasized as a preferred choice. It has been claimed that generating power from waste is somehow a "renewable" form of energy. This idea has been particularly strongly pushed by the plastics industry which is actively fighting attempts to reduce the amount of wasteful packaging. They know that the best alternative to landfill or incineration of non-recyclable waste is composting, which is not an option for plastics. Hence, future waste disposal strategies are likely to emphasize the reduction in the use of plastics. However, since all plastics are produced by the use of fossil fuels, burning them can never be regarded as a sustainable or renewable use of resources.

Incinerators are a very capital intensive investment which demand a steady stream of waste to burn. To be assured of their viability companies need long-term contracts, in most cases 25 years, with local authorities who supply the waste. This locks authorities into

providing high levels of waste for decades and thus discourages waste minimization.

Incineration does not promote waste reduction and recycling; it merely postpones the day when waste minimisation is addressed properly. The real issue is whether we should be designing products at all that end up with waste that requires incineration. Ruth Grier, Minister for the Environment for the government of Ontario, Canada, has said: "**Incineration is inconsistent with reduction, re-use and recycling because it relies on a steady, large quantity of mixed waste. It is a superficial solution which does not attack the root of the problem - we must waste less**".**(6)** Ontario is one of an increasing number of authorities around the world which has banned all future municipal solid waste incinerators.

Incineration still produces ash. It can comprise about 25% by weight and must be landfilled. Thus incineration means incineration plus landfill. The ash is far more toxic than ordinary domestic refuse, and is particularly expensive to dispose of. It contains considerable quantities of heavy metals, such as lead, cadmium, and mercury., and may contain even more toxic elements such as organohalogens, which are produced in the combustion process. It provides a particular threat to groundwater. Contained, monofill landfill sites must be found, and very carefully maintained.

Health Effects :

This century has seen regular scares about health risks from various sources, e.g., lead, tobacco, pesticides, asbestos, radioactivity, CFC's, etc. The common factor is that action is taken after a problem has occurred, and the damage is done. Common sense suggests that we should not be adding chemicals to the environment about which we have limited knowledge, especially when these chemicals are known not to break down and can accumulate in peoples bodies. In other word, we should believe in the precautionary principle, that is, don't indulge in processes or activities which many be damaging until it can be proved beyond reasonable doubt that they are safe.

The key question that must be answered regarding the incineration is this - what is the long term effect on the human body of very small amounts of pollutants? An incinerator may well meet standards on pollutants but that is not a guarantee that the pollutants will not cause harm. As in the past, standards will no doubt be tightened in future following research of harmful effects. The incinerator may well not pollute as much as road traffic in the area. But the pollutants from the chimney will add to the existing pollution, and they will not vanish. They will be dispersed over a wide area into people's bodies where they will accumulate in the body's fatty tissue. This process is known as bioconcentration. If pollutants were to pass naturally through bodies, bioconcentration would not exist. But bone and fat are able to capture some of the most deadly pollutants. The consequence is that the levels of pollutants in bodies are far higher than background levels in the environment..

Pollution from Incinerators :

Incinerators create waste that is poisonous, and poses significant threats to public health and the environment. No methods have been developed for continuous identification of all the potentially dangerous gases and particulates in incinerator stacks. Even under the strictest of standards "state of the art" incinerators emit chemicals that have escaped combustion as well as newly formed products of incomplete combustion - thousands of different chemicals of which only a small fraction have been identified.

Around a quarter by weight of the waste that is put into incinerators is left after burning this has to be landfilled. These wastes are particularly poisonous. Many heavy metals react to form highly volatile organic compounds by burning. An incinerator could typically emit 27 different heavy metals to air, all 210 known types of dioxins and furans, as well as up to 400 other organic compounds, only a fraction of which have been subject to rigorous study as to their health effects. The poisonous materials in the fly ash which goes to landfill are rendered more leachable by incineration, thus increasing their pollution potential.

Long Term Effects :

The build up of toxins associated with incinerators could take place not just in individuals lifetimes, but across generations. In 1990 the Munich Region of the German Medical Association stated that: **"According to the German Health Agency, milk from nursing women is twenty times more contaminated with dioxin than cow's milk. The multitude of contaminants a woman has accumulated in her body over a time span of two to three decades reappears during nursing and is transferred to the baby." 1)** In Germany, some pediatricians are already telling young women to limit their breast-feeding to three or four months.While not all these dioxins come from incinerators, a Dutch Government report stated in 1989 that: **"The contribution of waste incineration to PDCC (dioxin) and PCDF (furan) contamination of the general population amounts to approximately 30 per cent.... Locally in the vicinity of facilities, this may be considerably higher. Waste incineration constitutes the greatest point source of emission of these substances".**

One of the most disturbing aspects of the links between these chemicals and cancer is that we may not be dealing with a tiny statistical increase. The most recent statistical information on cancer is that despite the vast sums of money spent on research ($2 billion a year in the US alone), both the cancer rate and the mortality rate from cancer is still increasing worldwide. Likewise, scientists have recently discovered that male fertility levels have dropped by as much as 50% in the last 30 years. The blame for these facts is been increasingly put on the numerous chemicals we emit into the atmosphere and our water supplies. In particular, those chemicals which are oestrogenic (i.e. they mimic the effects of the female hormone oestrogen in our bodies) may be the prime culprits. Dioxins and furans are known to be powerful oestrogenics. Last year, 73 scientists signed a letter to the U.S anti-cancer agency, the National Cancer Institute (NCI), accusing it of over-emphasizing diet and lifestyle as a cause of cancer, while ignoring the role of chemicals in the environment. The NCI itself believes that 8% of cancers are chemically related. The dissenting scientists

believe it could be twice that figure. Several senior U.S scientists now believe that oestroegenics are the primary suspect.

The link between oestrogenic substances and cancer is cause enough for concern. However, the possible health effects of chemicals known to disrupt the endochrinal (i.e.hormonal) system are much broader. The following is a quote from a multidisciplinary group of experts looking at this problem:

"We are certain of the following: A large number of man-made chemicals that have been released into the environment...have the potential to disrupt the endocrine systems of animals, including humans...The impacts include thyroid dysfunction in birds and fish; decreased fertility in birds, fish, shellfish, and mammals;....metabolic abnormalities in birds, fish and mammals; demasculinization and feminization of male fish, birds and mammals;....It is urgent to move reproductive effects and functional teratogenicity to the forefront when evaluating health risks. The cancer paradigm is insufficient because chemicals can cause severe health effects other than cancer....Impacts on wildlife and laboratory animals as a result of exposure to these contaminants are of such a profound and insidious nature that a major research initiative on humans must be undertaken".

Another major health problem associated with incinerators has only very recently come to light. Incinerators are known to produce particularly fine particulates. A major recent study found that there is a much stronger statistical link between fine particulates and mortality rates from lung cancer and cardiopulmonary diseases than with any of the other major forms of pollution measured (e.g., Carbon Monoxide, Sulphur Dioxide). In fact, the finer the particulates measured, the closer the correlation appeared. A recent report in "New Scientist" magazine estimated that approximately 10,000 cases of excess mortality every year could be attributed to sub 10 micron particulates.

The studies mentioned above are very recent and their implications are not clearly understood. No one knows the long term effect of low amounts of poisonous, persistent chemicals in the air. But it is

known that they enter the human body and stay there. Surely, therefore, given the growth in cancer and so many discoveries after the event about the effects of poisonous chemicals, common sense dictates extreme caution. As with so many other areas of human activity the future is likely to bring unwelcome revelations about the environmental effects of practices which were said to be safe at the time. Perhaps the best summary of these results was provided by Dr. Paul Connett, Associate Professor of Chemistry at St. Lawrence University:

"The Knowledge that high-temperature incineration is capable of producing such contaminants should make any prudent person pause before sanctioning more of these plants, until we fully understand the fate, effects and amounts currently being emitted".

DIOXINS :

Dioxins are probably the most studied chemical compound in the world today, yet there is still much about them that is unknown. What we do know, however, is enough to have many people calling for action.

Although frequently referred to in the singular form, "dioxin," chlorinated dioxins are actually a group of chemicals that includes 75 dioxins, 135 furans and 209 polychlorinated biphenyls (PCBs). They are grouped together because their chemical structure is very similar, as are many of their suspected effects. The most potent form of dioxin, 2,3,7,8-tetrachlorodibenzo-p-dioxin, is often referred to as 2,3,7,8-TCDD.
Unlike many chemicals that have gained notoriety over the past 25 years of increasing environmental awareness, dioxin is not a "product," or an intentionally produced substance, like DDT, Agent Orange, or Alar. Dioxin is a by-product of many industrial processes such as the incineration of garbage, medical waste or toxic chemicals; the bleaching of paper pulp with chlorinated compounds; production of polyvinyl chloride (PVC) plastics; the manufacture of some chlorinated pesticides; secondary smelting of copper; and other activities. In order to produce dioxin, one needs

organic matter (carbon), chlorine, and a chemically or thermally reactive environment, such as a pesticide production facility or an incinerator.

History of dioxin

Dioxin first gained widespread public attention in the U.S. when it was found as a contaminant of Agent Orange, a chlorophenoxy herbicide known for its use as a defoliant in Vietnam. Military use of Agent Orange was banned in 1970. One component of Agent Orange, 2,4,5-trichlorophenol (2,4,5-T) was cancelled in the U.S. in 1987 after it was found to be contaminated with several forms of dioxin. The use of the other half of Agent Orange, 2,4-D, has been restricted but it remains a common ingredient in many lawn care "weed and feed" preparations and is still used on some food crops, such as wheat.

Dioxin contamination also led to the evacuation of such communities as the neighborhood in Niagara Falls, New York which came to be known as "Love Canal," and Times Beach, Missouri. Accidents at pesticide plants in Nitro, West Virginia in 1949, a BASF facility in Germany in 1953, and in Seveso, Italy in 1976 also exposed large groups of people to high doses of dioxin.

Health effects

Dioxin has gained so much attention because years of scientific research have shown it to be one of the most toxic substances known to humans. It has been linked to a wide variety of health effects in people and in animals:

- cancer of the soft or connective tissue, lung, liver and stomach, and non-Hodgkin's lymphoma;
- effects on the male reproductive system, including lower sperm counts, testicular deformities, decreased sex drive, alterations of male hormone levels, and feminization of hormonal and behavioral responses;

- effects on the female reproductive system, including hormone changes, miscarriage, decreased fertility, changes in the menstrual cycle, and endometriosis;
- birth defects such as cleft palate, deformities of the reproductive organs and genitals;
- effects in offspring such as neurological and developmental problems, delayed puberty and reduced fertility;
- damage to the central nervous system;
- liver damage;
- thyroid dysfunction;
- immune system damage, including increased susceptibility to infectious disease and to cancer.

Recently, dioxin has gained attention as one of more than 50 chemicals known or suspected to disturb the hormone system of humans or animals. These chemicals are commonly referred to as "endocrine disrupting chemicals" or "hormone disrupters." Endocrine disrupting chemicals are of particular concern because the health effects show up not in the exposed parent, but in their offspring. Hormones regulate many processes in the body, including sexual development, reproduction and growth. Hormones are produced in exquisitely tiny amounts, yet exert monumental effects. Thus, scientists are concerned that even very, very small doses of dioxin or other endocrine disrupting chemicals could produce life-altering changes in animal offspring and human babies.

Dioxin in the environment

Dioxin is a very stable chemical, resisting natural breakdown processes for extremely long periods of time. The U.S. Environmental Protection Agency (EPA) estimates that the half-life of dioxin in soil, for instance, is 10 to 30 years. Instead of breaking down, even small amounts of dioxin released into the environment, build up to higher and higher levels over time. It accumulates. Polar bears, whales, other animals and people even in the most remote areas carry high dioxin concentrations in their bodies.

Dioxin is a fat-soluble compound, so it concentrates in fat; it is not very water-soluble. It is also difficult to break down in the body, so it tends to persist in the environment and to build up in the food chain. Thus, when animals at the top of the food chain (including humans) eat other animals or animal products, such as fish or milk, they will take in some of that animal's body burden of dioxin along with the nutrients in the food. The U.S. Environmental Protection Agency (EPA) has estimated that 90 percent of our dioxin exposure comes from our food. In a "typical" American diet, three-quarters of that exposure comes from beef and dairy products.

Most dioxin enters the food chain in two ways. The Center for the Biology of Natural Systems has researched dioxin emissions from combustion sources like incinerators and cement kilns and found that dioxin can attach to dust particles or water vapor and travel up to 1000 miles from the facility. The dioxin then falls to the ground, where it often lands on hay or grazing pastures. The dioxin particles stick to the grass or hay and thus are eaten by animals such as dairy or beef cattle. Because of its fat solubility, the dioxin concentrates in the beef fat or milk fat and is thus passed on to the human consumer in beef, milk or dairy products.

The other main source of contamination comes from wastewater discharged by pulp mills that bleach paper pulp with chlorinated compounds. Chlorine combines with organic matter from the wood to form more than 1000 compounds referred to as "organochlorines," of which dioxin is one. These organochlorines are released with wastewater into surface waters such as lakes or rivers, where they can build up in fish and other aquatic wildlife. For people who rely on fish for a large portion of the protein in their diet, this can also be the major source of their dioxin exposure.

Greater Health Risks With Indigenous Peoples

Recent studies have found that Indigenous Peoples are at greater risk for toxic illness due to the lack of an enzyme. The federal Agency for Toxic Substances and Disease Registry reported that Indian tribes may be "at higher risk than average populations due to

high wild food consumption, contaminated drinking water sources, high levels of radioactivity found on reservations, and high fish consumption rates." Toxic response syndrome (TRS) remain an invisible epidemic among Indigenous Peoples because its symptoms often mimic other diseases. The issue of multiple chemical sensitivity (MCS) is a growing concern among Indigenous populations.

Dioxin Impacts Our Women, Elderly and Children

In many of our traditional Indigenous communities, elders still eat the fatty material of fish which has very high concentrations of dioxin and other contaminates such as mercury. Because we cannot effectively detoxify our bodies or get rid of dioxins, these chemicals can now be detected in all our organs, with high concentrations in our fat and mother's milk. The only known way to reduce one's body burden of dioxin is through breast feeding. Children bear the highest exposures. Dioxin can cross the placenta, during the most important part of child development. The child is exposed to dioxins that have built up in the mother's body during her life. And mother's milk from U.S. women contains the highest concentrations of all - up to 500 times higher than cow's milk. According to EPA, an average breast feeding infant is subject to daily dioxin doses 20 to 60 times higher than those of an average adult. Again, breastfeeding of children of Indigenous Peoples is a cultural and spiritual value that is part of traditional teachings. Dioxin also impacts the reproductive systems of men lowering sperm count.

Other Impacts

Exposure during fetal or infant development can lead to hormonal changes, birth defects, and reduced growth. More alarming, tiny doses of dioxin can have effects that become obvious only later in life, such as impaired intellectual development, infertility, and other reproductive problems at puberty. Dioxin has also been linked to

the risk of endometriosis (uterus-womb), diabetes, and other diseases. Dioxin acts like an "environmental hormone," wreaking havoc on many of the body's natural biochemical processes. When dioxin enters the body it passes through cell membranes and combines with a natural receptor protein that allows dioxin to enter the cell nucleus. Dioxin then interacts with DNA, turning on genes that control many biochemical reactions, such as the synthesis and metabolism of hormones, enzymes, growth factors, and other chemicals. In other words, it changes how our body acts.

How to get dioxins out of the environment?

It is important to remember that eliminating animal fat from one's diet will not make the dioxin problem go away; it will put farmers and fishers out of business while allowing the polluting industries to keep discharging dioxin into the environment. The only way to address the dioxin problem is to phase out the processes that produce dioxin.
Alternatives are readily available for many of the processes that generate dioxin. Indeed, dioxin expert Dr. Paul Connett has said, "If dioxin were a product [rather than an unwanted by-product], it would've been banned years ago."

Clean production technologies, waste reduction, reuse and recycling can eliminate the need for garbage and hazardous waste incinerators and cement kilns.

Medical waste incineration, considered by EPA to be one of the top sources of identified airborne dioxin emissions, could be replaced with alternative technologies such as autoclaves or microwaves. Recycling and reusable medical supplies can greatly reduce the amount of waste needing disposal. Many of the PVC products used in a health care setting as well as in the home have readily available substitutes.

Nearly 60 percent of the PVC used in the U.S. goes into construction materials, and there, too, alternatives are available for windows, siding, plumbing pipes and fittings, and other fixtures.

The pulp and paper industry can convert to processes that are "totally chlorine-free" (TCF), meaning that no chlorinated agents are used in bleaching.

CONCLUSIONS :

It is not difficult to see why incineration seems to provide an easy and quick solution to the problems involved in waste disposal. But this may be result of a short-term economic situation which could have long disastrous long-term results.

But, you may ask, how can we afford the alternatives? The simple answer is that the most recent studies show that a combination of reduction, reuse, recycling and composting not alone diverts more material from landfill than incineration ever can, but actually **costs less.**

NATIONAL WASTE MANAGEMENT STRATEGY

- Wherever possible, avoid creating wastes
- Where wastes are unavoidable, recycle them, if possible
- Where wastes cannot be recycled in the form of materials, recover energy from them
- When the foregoing options have been exhausted, utilise the best practicable environmental option to dispose of waste

WHY INCINERATION?

- Large increase in solid wastes, particularly non biodegradable wastes-pesticides, plastics, etc.
- Shortage of land/potential land & aquifer contamination
- Safe disposal/energy recovery

WHAT IS DIOXIN?

- Most studied chemical compound
- Still much less known; but what is known is enough to call for action
- Singular, generic name dioxin but actually includes 75 dioxins, 135 furans and 209 pcb's; similar structures and similar effects
- Most potent 2,3,7,8 – tetrachlorodibenzo – p – dioxin or 2,3,7,8 – TCDD
- Unlike other notorious chemicals, eg. DDT, Alar, Dioxin is not a chemical of necessity; but a by-product of industrial processes

WHERE DOES DIOXIN COME FROM?

- Major source (96%) comes from burning of chlorinated compounds; eg. from garbage, medical waste and toxic chemicals
- Bleaching of paper with chlorinated compounds
- Production of PVC plastics, chloriated pesticides and secondary smelting of copper
- To produce dioxin – we need organic matter ©, chlorine and a reactive thermal environment
- It was earlier believed that dioxins were produced by low temperature combustion (<1400 ^{0}C)
- But recent research shows that more dioxin is formed in the stacks where the fly ash acts as a catalyst
- Further dioxins have been formed from non-chlorinated compounds also
- Wet garbage produced more dioxins than dry garbage

HISTORY OF DIOXIN

- Public attention as a contaminant of agent orange, a chlorophenoxy herbicide used in Vietnam war; banned in 1970
- 2,4,5-T another herbicide banned in 1987; 2,4 – D still used as a pesticide for lawns and food crops
- Dioxin contamination associated with many environmental episodes, Love canal, Times beach and industrial accidents Seveso (Italy) BASF (Germany)

WHAT ARE THE HEALTH EFFECTS OF DIOXIN?

- Dioxin has gained so much attention as scientific research has shown it to be one of the most toxic substances known to humans. It has been linked to a wide variety of health effects in people and in animals:
- Cancer of the soft or connective tissue, lung, liver and stomach, and non-Hodgkin's lymphoma;
- Effects on the male reproductive system, including lower sperm counts, testicular deformities, decreased sex drive, alterations of male hormone levels, and feminization of hormonal and behavioral responses;
- effects on female reproduction system including hormone changes, miscarriages, endometriosis etc.
- birth defects, deformities in offspring, neurological and developmental problems in children
- damage to central nervous system, liver damage, thyroid dysfunction and immune system damage including increased susceptibility to infectious diseases

HEALTH EFFECTS

- Recently Dioxin has been shown to be one of 50 endocrine disrupting chemicals which are of particular concern because the effects show up not in the parents but in the offspring
- Hormones produced in tiny amounts exert great effects. Thus even very small doses of dioxin could produce life-altering changes

WHAT DO YOU MEAN IT DOES NOT BREAKDOWN?

- Dioxin is a very stable chemical, resisting natural breakdown processes
- Estimated half-life of dioxin in soil is 10 – 30 years
- Instead of breaking down it bioaccumulates in food web organisms

WHERE DOES THE DIOXIN ACCUMULATE?

- Dioxin is not soluble in water but are powerfully attracted to fats & oils. As a result they accumulate in the tissues of living things and multiply in concentration as they move up in the food chain
- 90% of our dioxin exposure comes through food supply particularly through fish, meat and dairy products
- A German study revealed breast milk from women is 20 times more contaminated than in cow's milk
- Indigenous people, women, elderly and infants are at greater health risk

DIOXIN IN THE ENVIRONMENT

- Research on dioxin emissions from combustion sources have shown that dioxin can attach to dust particles or water vapor and travel upto 1000 miles from the incinerator. The dioxin then falls to the ground, often grazing grounds and enters the cattle.
- The other major source is from pulp mills bleaching with chlorine compounds where dioxins are released in the effluents

HOW TO GET DIOXINS OUT OF THE ENVIRONMENT

- The only way to address the dioxin problem is to phase out the processes that produce dioxin
- Alternatives are readily available for many of the processes that generate dioxin. Indeed, dioxin expert Dr. Paul Connett has said "If dioxin were a product (rather than an unwanted by-product), it would've been banned years ago".
- Clean production technologies, waste reduction, reuse and recycling can eliminate the need for garbage and hazardous waste incinerators and cement kilns.
- Medical waste incineration considered to be one of the top contributors of airborne dioxin could be replaced with alternative technologies, eg. autoclaving or microwave
- Physicians for social responsibility has resolved to reduce the emission of dioxin from medical waste
- Most of the PVC healthcare products have readily available substitutes
- Nearly 60% of the PVC used in construction industry, pipes and fittings etc. can be replaced by alternatives
- Pulp and paper industry can use chlorine free bleaching

CONCLUSIONS

- Dioxins are highly dangerous compounds with high health risks to not only this generation but also to future generations
- Waste incineration is a potential source of dioxins and hence should be carefully evaluated

RAINWATER HARVEST

RAINWATER HARVESTING – CONCEPTS AND METHODOLOGIES AT MICRO LEVEL AS ADOPTED BY METROWATER BOARD

Introduction

In most of the cities, the water supply sector is facing a number of problems and constraints. The pace of urban development and the increase in population in the urban areas have resulted in exploitation of water resources to the extremes. Fresh water resources are being heavily exploited to meet the demands of urban populace. Failure of monsoon makes the situation worse. As surface water sources fail to meet the ever increasing demands, ground water reserves are tapped, often to unsustainable levels. Chennai city and its suburban areas often get affected with water scarcity during the periods of low rainfall. As the dependence of ground water increase during such periods the ground water table depletes father than normal rate resulting in dry wells. In addition to quantity, we also face problems of water quality due to over extraction of ground water. Unplanned and uncontrolled extraction of ground water would disturb the hydrological balance along the coastal areas which results in possible sea water intrusion. Hence, it is necessary to take up measures to conserve and augment the renewable water resources in all possible ways. Ground water recharge by rain water harvesting (RWH) is the simple and cost effective way.

Reason for water crisis

Rain is the first form of water that we know in the hydrological cycle, hence is a primary source of water for us. Rivers, lakes and ground water are all secondary sources of water. In present times, we depend mainly on such secondary sources of water. In the process, it is forgotten, that rain is the ultimate source that feeds all these secondary sources and remain ignorant of its value. Water crisis situation occurs only because, effective collection and storage of rain water has been ignored. The potential of rain to meet water demand is tremendous. Unless people are involved in conserving

rain water from individual households to industrialists, it would be very difficult to meet the looming water crisis.

Rainwater Harvesting

Water harvesting means to understand the value of rain and to make optimum use of rain water at the place where it falls. In scientific terms, water harvesting (broadly) refers to collection and storage of rain water and also other activities such as harvesting surface water, extracting ground water prevention of losses through evaporation and seepage.

In general, water harvesting is the activity of direct collection of rain water. The rain water collected can be stored for direct use or can be recharged into the ground water.

Need for Rainwater Harvesting

We get a lot of rain, yet we do not have water. Why? Because we have not realised enough the value of each rain drop. Ironically, even Cherrapunji which received about 11,000 mm of rainfall annually suffers from acute shortage of drinking water. This is because the rain water is not conserved but allowed to drain away. Thus it does not matter how much rain we get, if we don't capture or harvest it.

The annual rainfall of Chennai is computed to be 1100 – 1200 mm. This is higher compared to the country's average of 800 mm. However, this rainfall occurs during short spells of high intensity. Because of such intensities and short duration of heavy rain, most of the rain falling on the surface tends to flow away rapidly, leaving very little for the recharge of ground water. Also, due to the fast rate of urbanisation, the city has become a concrete jungle and and it is very difficult to find open surfaces which would enhance the recharge of ground water. This highlights the need to implement measures to ensure that the rain falling over a region is tapped as fully as possible appropriate through water harvesting for recharging the ground water acquifers.

How much water can be harvested?

The total amount of water that is received in the form of rainfall over an area is called the rain water catchment / endowment of that area. Out of this, the amount that can be effectively harvested is called the water harvesting potential.

The collection efficiency accounts for the fact that all the rain water falling over an area cannot be effectively harvested. Consider a building with a flat terrace area of 100 sq. m. The average annual rainfall in Chennai is approximately 1100 mm. In simple terms, this means that if all the rain that falls on the terrace is retained, then in one year there will be rainwater on the terrace floor to a height of 1100 mm.

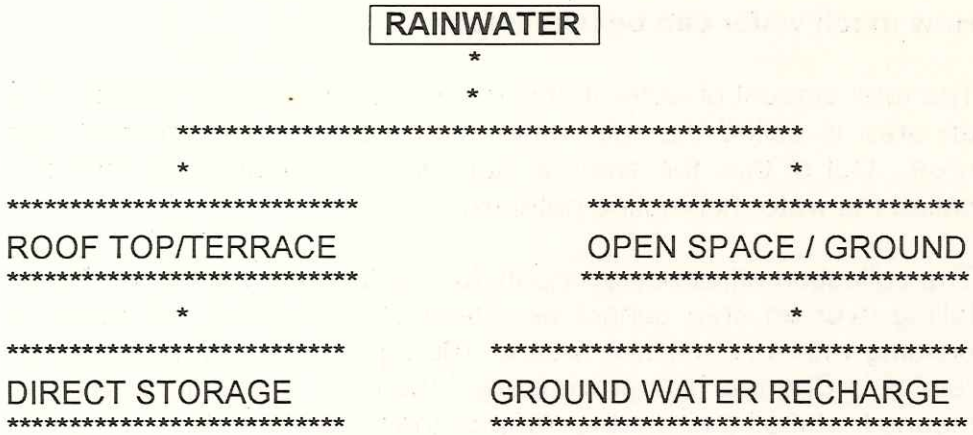
Area of Terrace	:	100 sq.m
Height of Rainfall	:	1.10 m (1100 mm)
Volume of Rainfall over the Terrace	:	Area x Height of rainfall
	:	100 sq.m x 1.10 m
	:	110 cu.m (1,10,000 litres)

Assuming only 60% of the total rainfall is effectively harvested.
Volume of water harvested = 66,000 litres (1,10,000 x 0.6 m)

How to harvest Rainwater?

Broadly, rain water can be harvested for two purposes.

1. Stored for ready use in containers above ground or below ground
2. Charged into the ground for withdrawal later (ground water recharging)



As mentioned, rainwater falling on the terrace can be collected through pipilines/drains and stored in a storage tank for direct use or diverted into a well for ground water recharge. Rainwater fall on the open spaces around the building may also be diverted for recharge purpose.

Should rainwater be stored directly or recharged?

The decision whether to store or recharge rainwater depends on the rainfall pattern of a particular region. For example, in places where rain falls throughout the year (baring few dry periods), one can depend on a small domestic sized water tank for storing rain water, since the period between two spells of rain is short.

On the other hand, in areas where the total annual rainfall occurs only during 1-2 months, the water collected during the monsoon has to be stored throughout the year, which require huge volumes of storage containers and as well as some treatment processes. Therefore, considering the other option viz. ground water recharge, it is more feasible to use rain water to recharge ground water aquifers so as to enable us to draw water during the rest of the year rather than storing in large containers which is always not feasible.

Benefits of RWH

1. RWH helps to conserve and augment the storage of ground water aquifers thereby improving the ground water table.
2. Over extraction of ground water, in coastal areas like Chennai, leads to saline water intrusion. Recharging the ground water aquifer helps arrest this saline water intrusion.
3. The quality of ground water in many pockets of Chennai city is either poor or not potable due to the presence of unfavourable hydrogeological formations such as clay. Continuous recharge of ground water using rain water helps to improve the ground water quality considerably.
4. The buildings which are constructed on clay soil formations are prone to develop cracks during dry periods. As RWH helps to sustain the moisture level in the sub-soil, such adverse conditions could be avoided.
5. The scope for natural recharge have become minimal in urban areas like Chennai city and inconveniences like flood and water stagnation due to *even* short spells of rainfall have become a reality. RWH helps avoid such situations.

Recharge of Ground Water Aquifers

Rainwater may be collected and charged into the ground water aquifers through the following methods:

- Roof Top Harvesting
- Harvesting rainwater from open spaces

1. Roof Top Harvesting

Roof Top harvesting has been practiced since ages and even today it is practiced in many places throughout the world. As we know the rain water collected from the terrace is free from any bacteriological contamination (except small amount of dust and other silt particles which can be filtered) it can be diverted to the existing wells/borewells which are in use as detailed below.

a. *Open well method*

This is the simple method of RWH (FIG.1) in which all the rain water falling on the terrace of the building is collected through pipe lines and diverted into an existing open well through a filter tank/chamber. The filter chamber helps to filter fine dust, silt and other small floating particles such as leaves etc. which are normally found on the terrace. (A mesh filter/grill may also be provided at the mouth of the drain pipe on the terrace to arrest larger particles).

The size of the filter chamber depends on the amount of rainwater flows from the terrace. Normally this may be of 2' x 2' x 2' size. The bottom of the chamber is filled with broken bricks followed by gravels and coarse river sand on the top. The location of the chamber is preferred based on the site conditions either below or above ground level.

b. *Borewell method*

As in the case of open wells, the rainwater from the terrace may be diverted to a borewell also (Fig. 2). In this case, it is to be kept in mind that during excess rainfall, the rate of recharge may not match the rate of rainfall. In such situations, a percolation pit has to be provided nearby to divert the excess flow of rainwater.

2. RWH in open spaces / Roof Top Harvesting

Various kinds of recharge structures are possible which can ensure that rainwater percolates in the ground instead of draining away from the surface. While some structures promote the percolation of water through soil strata at shallow depth (e.g. percolation/recharge pits, recharge trench, etc.) others conduct water to depths from where it joins the ground water (e.g. percolation pit with bore trench with bores/recharge well etc).

At many locations, existing features like pits, tanks and wells can be modified to be used as recharge structures, eliminating the need to construct any structures afresh. A few commonly used simple and cost-effective methods are given under. Other innovative and combinations of these methods are also possible and they can be used as per the site/building conditions.

Types of RWH	Cost
1. Percolation Pit	Rs. 650/- unit
2. Percolation Pit with bore	Rs.1200/- unit
3. Recharge Trench	Rs. 650/- unit 1x1x1.5m
4. Recharge Trench with Bore	Rs. 900/- metre
5. Recharge well (shallow/small dia)	Rs. 4100/-
6. Recharge well (deep/large dia)	Rs.7500/-

Basically these are the common methods from which we can select any type which is suitable for the site conditions such as the areal extend and subsoil conditions. However, no. of units of RWH structures may be increased based on the extent of the open space available such as in a large apartment/commercial complex the volume of rainwater collected is more. For a typical RWH arrangement in individual houses, apartments and other similar buildings a schedule of quantities as specified in Annex 1 may be referred.

Role of Metrowater Board in Rainwater Harvesting

For a rain deficient and coastal city like Chennai, the importance of rainwater harvesting (RWH) would need no justification. There is a persistent threat posed to the 'fragile' aquifer by the possibility of sea water intrusion, also threats posed to the otherwise shallow and delicate aquifer by indiscriminate extraction of ground water are well known. Keeping this in view, as a macro level strategy Govt. of Tamilnadu have introduced 'Chennai Metropolitan Area Ground Water (Regulation) Act, 1987' which covers of the whole of Chennai City and 243 revenue villages around it. It is due to the implementation of this Act, the water table in the Southern part of Chennai city which was on an average depth of 8 metres before

1988, has risen upto an average depth of 400 metres below ground level which means that there is about 4 metres net increase. After the implementation of the Act coupled with certain other measures such as construction of check dams across Koratalaiyar river, there has been phenomenal increase/rise in the ground water table. As a matter of fact, during the current year, Metrowater Board has been able to increase the drawal from 55 MLD to the present 100 MLD of water (50% of city supply) from these Wellfields only due to these measures undertaken by CMWSSB during the last five to six years.

In this background, as microlevel strategy now CMWSSB has decided to embark upon popularising the RWH techniques among the residents of Chennai city, as also in the neighbouring areas. Realising the fact that some sort of regulatory mechanism would be necessary for our people to act upon these measures, as a first step Metrowater worked out a sort of 'statutory arrangement' alongwith CMDA and Chennai Corporation. Accordingly, Planning Permission Applications for special buildings and multi-storeyed buildings are being admitted only if there is a proposal for conservation of rainwater as proposed by CMWSSB.

While sanctioning water and sewer connections, completion of RWH arrangements is being insisted by Metrowater Board for all premises having buildings of Ground + 3 floors and above, and special buildings. As per the recent initiatives to sensitise the citizens of Chennai city about the importance of RWH following regulatory changes have now been put into effect.

1. Making RWH structures has been made mandatory for all the buildings (irrespective of size and area) when approaching CMWSSB for new water and sewer connections.
2. Further it is also to be declared by the owner that the RWH structures would be properly maintained by the owner / owners /occupiers and should not be dipensed with in future and
3. The Corporation of Chennai is to admit /accord planning permission for all new (irrespective of size and area) buildings only if there is a proposal for construction of RWH structures.

Considering the importance of RWH in conserving the precious ground water resource, in the recent couple of weeks the Board has taken initiative to constitute a fully dedicated 'Rainwater Harvesting Cell' headed by the Senior Hydrogeologist together with other supporting staff. The main objectives are as under:

1. *Broad Objectives*
   - to create public awareness on the importance of Rainwater Harvesting among the public
   - to popularise simple and cost effective Rainwater Harvesting methods in order to attract larger participation of the public

2. *Specific Objectives*
   - to offer technical guidance/assistance about the method to be adopted based on the local geological formations and site conditions
   - to monitor water level and water quality in the Rainwater Harvested areas and wells. (Both existing and proposed areas/wells)
   - to assure proper maintenance of the Rainwater Harvesting structures after installation
   - to do and undertake anything which would promote Rainwater Harvesting (both in individual houses and public places)

In order to create public awareness on RWH booklets, pamphlets and brochures have been prepared and distributed to the public including schools and colleges. Meetings are being arranged for the benefit of public through Exnora, Rotary Club and Residential Welfare Associations. With a view to popularise the RWH techniques and also to provide to the citizens cost effective solutions, CMWSSB has created several models, detailed designs etc. which are available in the form of booklets. In the recent past, electronic and print media are being used to dessiminate the related information quite vigorously. Around 300 house / apartment owners contacted RWH Cell of Metrowater Board for technical guidance to install RWH structures and the same is being offered.

Metrowater has also designed a short training programme to the needy public who would like to know more about the concepts and methods of RWH. These training programmes are being conducted in the Metrowater Resources Centre from August to September on all the days. Training on RWH is also conducted for the Executive Officers / Engineers of the adjacent Municipal Corporations and also to the Engineers of the Corporation of Chennai.

Corporation of Chennai in cooperation with Metrowater Board is implementing RWH structures in selected parks and playgrounds. PWD and TWAD Board are also implementing RWH structures in their buildings in cooperation with the Metrowater Board. Besides, all Government Departments have been addressed to implement RWH structures in their buildings.

CONCLUSION

The effectiveness of RWH would be felt only through a strong commitment from the micro level players, viz. the individual households, agencies, establishments, institutions and NGO's. In this context, CMWSSB believes that they could effectively serve to sensitise the above group to bring about the best so as to achieve the goal and sustain the ground water sources through cost-effective solution.

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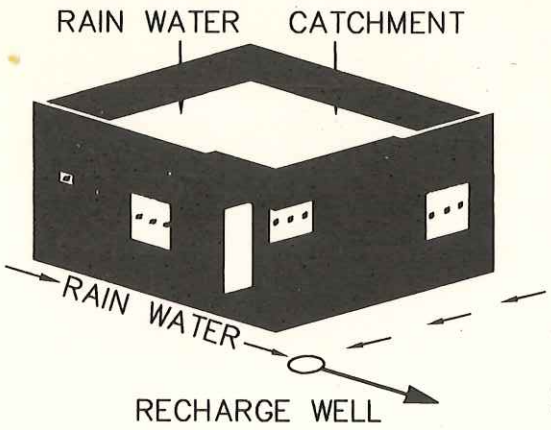
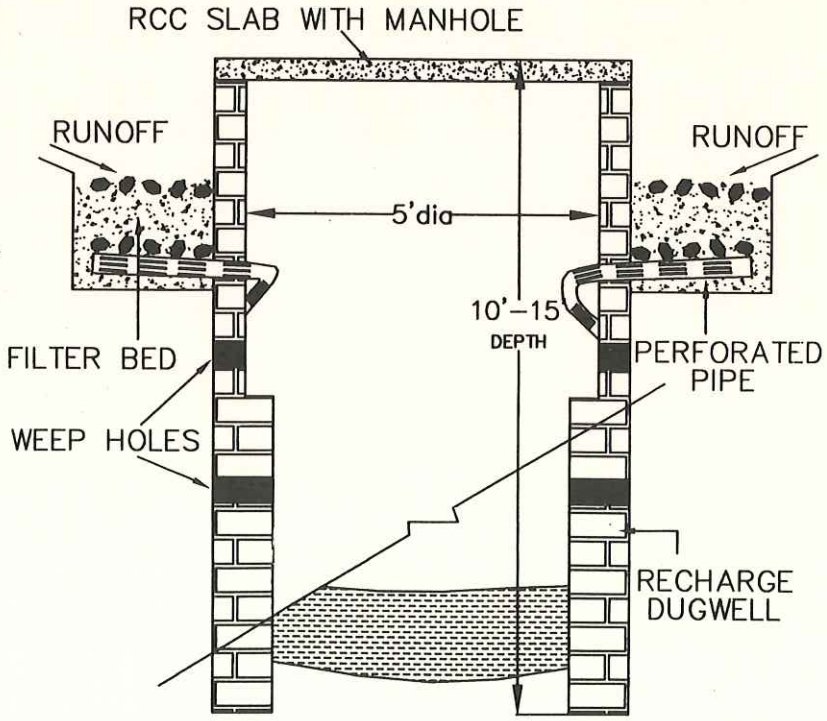
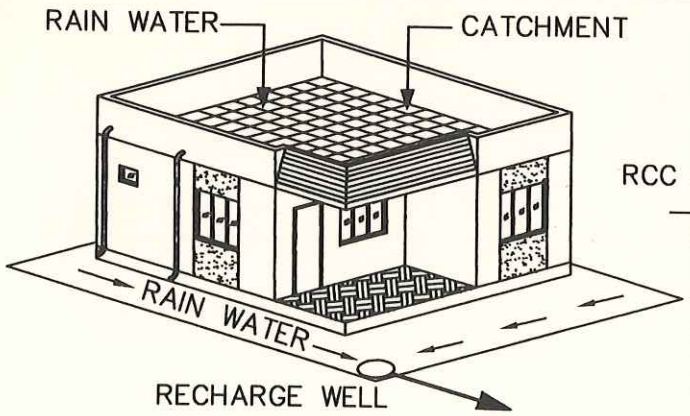
RECHARGE WELL (DEEP/LARGE)

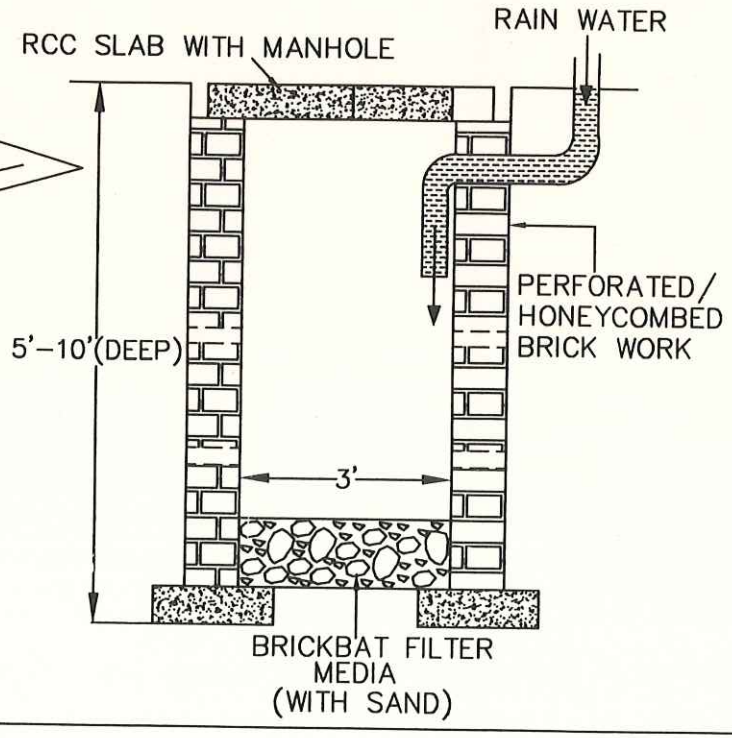




* Large diameter wells.
* Size : 5' dia with 10–15' depth.
* Constructed with brick/concrete rings.
* Side walls must be perforated.
* Covered with RCC slab/manhole.
* Suitable for clay sub–soil area.
* Approx.cost Rs.7,500/– per unit.

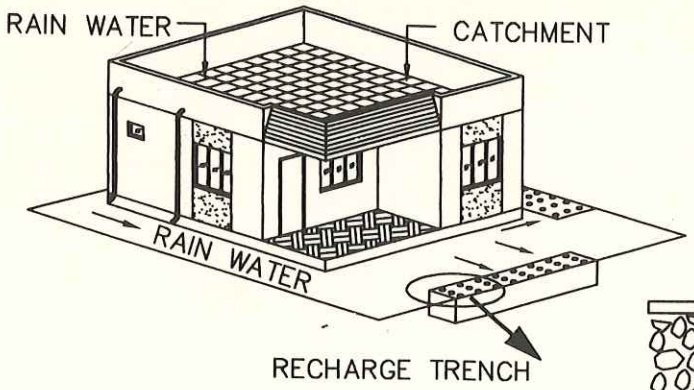
RECHARGE WELL (SHALLOW/SMALL)

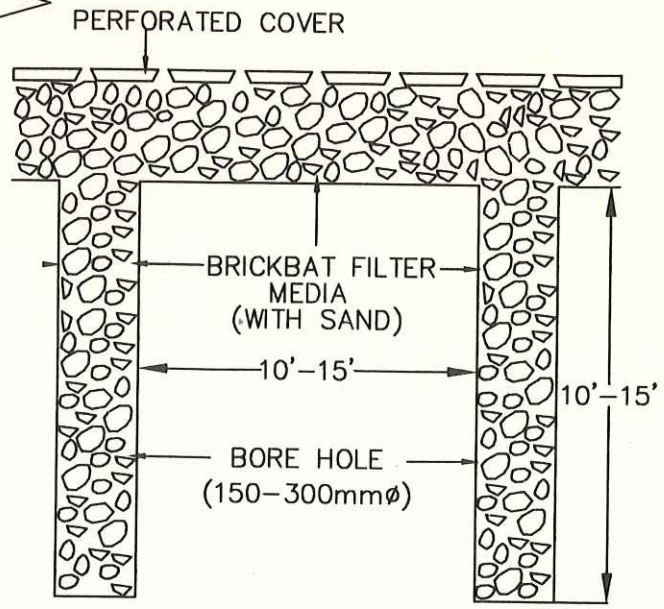




* Small diameter wells.
* Size: 3'dia with 5'–10' depth.
* Constructed with brick/concrete rings.
* Side walls must be perforated.
* Bottom (1') is filled with brickbats.
* Covered with RCC slab/manhole.
* Suitable for sandy sub–soil area.
* Approx.Cost Rs. 4,100/– per unit.

RECHARGE TRENCH WITH BORE





* Along the recharge trench boreholes has to be drilled.
* Borehole size: 150–300mm dia with 10'–15' depth.
* Filled with brickbats/pebbles
* Borehole Interval: 10'–15'
* Suitable for clay sub–soil area.
* Approx. Cost Rs.900/– per metre.

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