Oily Soil & Solids

Bioremediation

How it Looks

&

How it Works

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1 INTRODUCTION

1.1 WINDROW COMPOSTING

Windrow bioremediation is the production of compost by piling organic matter or biodegradable waste, like household garbage, animal waste, crop residues and hydrocarbon polluted materials in long rows (windrows). This method is suited to treating large volumes of waste into compost. These piles are turned and aerated with a special build mixer to apply nutrients, improve porosity and oxygen content, mix in or remove moisture, and redistribute cooler and hotter portions of the pile. Windrow composting is the most commonly used of method for the treatment of polluted soil. Process control parameters include the initial ratios of carbon and added nutrients, the amount of bulking agents added to assure air porosity, the pile size, moisture content, and turning frequency.

Compost windrow turners were developed to de-classify oil polluted soil and solids on a large scale. The windrow, emphasizing the “row” part means this method is applied on the ground surface and not “in the ground”. Windrowing (building rows) also allows accurate measurements of waste treated and declassified over the course of daily, monthly and yearly operations. Row building is a measurement of waste volumes and other ingredients used in the process. A drawing of our Row-Building Box is provided on page 7. Box volumes are recorded onto site forms as the rows are constructed and are used for Environmental audits. Rows are tended to using machines that straddle a windrow of various dimensions, which are dependent on the type, and volumes of the soil or solids waste to be treated annually. The most common row turner machine size used in an oily waste operations range from 2 m to 3 m in width and 1.2 m height. These can be seen from the photos included herein. Turner’s drive through the windrow at a slow rate of forward movement and depending on the drive speed determines the waste volume per hour that can be turned. The row turners common for treatment of oily soil-solids will turn a volume of waste at 1000 m^3/hr to 1500 m^3/hr. The row turners have a steel drum with paddles that are rapidly turning. As the turner moves

through the windrow, fresh air containing oxygen is injected into the compost by the drum/paddle assembly and waste gases produced by microorganisms are eliminated. The oxygen feeds the beneficial composting microorganisms and thus speeds up the composting process. This process is then extended by windrow dynamics as long as daily row turning is practiced.

To properly utilize a compost windrow turner, it is ideal to compost at a dedicated site where oily waste stocks are delivered and recorded (measured) into rows.

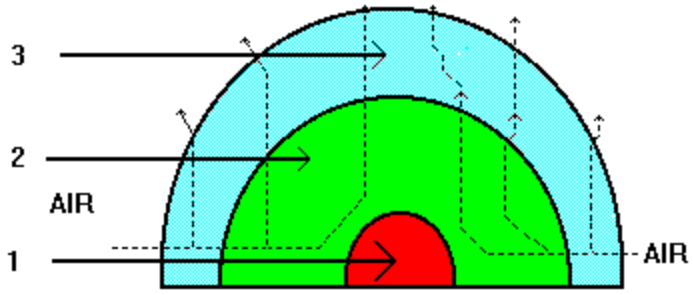
1.2 MICROORGANISM FARMING

There is no magic, no shortcuts, only MANAGEMENT when tending to a bioremediation operation. Composting is simply a matter of making the windrow conditions for the indigenous microorganisms optimum for reproduction and maximizing their population. When the microorganisms are kept at their optimum environmental conditions: plenty to eat, correct temperature, and lots and lots of fresh air (oxygen), they will perform their natural work - making finished compost, in record time without odors. When we mention “plenty to eat” we are referring to hydrocarbon or the oil contained in the waste. Hydrocarbon is a food source for the microorganisms hence the simple explanation of how the oil is depleted from the rows. Therefore a windrow starting with, for example 30% oil-on-soil, when properly managed will reach a specification of <1.0% in approximately 120 days.

Once the microorganisms are farmed and developed in the windrows they quickly develop into a specialized strain that are specific to the oily waste they feed on. This strain then becomes “indigenous” to the site and all matters of performance (degradation of oil from soil-solids) reach their highest levels to achieving the shortest environmental decomposition - declassification timeframe. Once the first row is started and microorganisms are in bloom (in the pile) and a second row is being build, a 5 gallon bucket of waste material taken from the first row is used to inoculate the second row and then continues in this manner each time a new row is build. As time progresses so does the microorganisms evolve into its indigenous strain specific for the waste being delivered to the site for treatment.

1.3 WINDROWS DYNAMICS

Windrow Dynamics is basically the natural or unassisted airflow and subsequent microorganism activity of an undisturbed windrow caused by the rising of heated air. The following cross sectional drawing illustrates the concept of Windrow Dynamics. In the above illustration, Zone # 1 represents what is referred to as the Dead Zone, or the anaerobic spot that normally begins immediately in a newly formed windrow. Zone # 2, which is the most active zone, is the hottest and has the most microorganism activity.



This Zone is the ideal zone. It can be the "Sweet Spot" of composting. It is possible, however, to have temperatures rise too high in this zone and begin to destroy beneficial microorganism. Zone # 3 is the least compact zone in the entire row. It is cooler than Zone #2 but warmer than Zone #1 microorganism activity in this Zone slows as the moisture evaporates and cooler air penetrates it.

1.4 FORMING OF THE ZONES

In most new windrows, Zone # 1 begins to form immediately and increases in size rapidly. The little Oxygen that exists is consumed rapidly, and the relatively high moisture content of the material begins to settle here. Zone # 2 is basically indefinable yet but begins to form as a result of an active Zone # 3, which remains small but active. If the row is not mixed and aerated soon it will all become Zone # 1. This is the most critical point because the odors generated can be the cause of site complaints. These Zones must be refreshed promptly. All the material must change places and preferably change zones. This is accomplished by completely mixing and aerating the windrow is to be done daily with windrow turner/aerator for 100% elimination of this problem.

1.5 BENEFITS OF 100% MIXING "DAILY"

Elimination of Odors, which are caused by:

A. Cold spots due to little or no aerobic microorganism activity.

B. Anaerobic pockets due to excess moisture collection.

C. Anaerobic pockets due to lack of oxygen.

D. Old clumps when they are finally broken open.

The benefits derived by the process:

1. It substantially increases the diversity of organisms working in the waste.
2. More complete biological breakdown of the material.
3. The finished product is consistent.
4. Insuring the broadest variety of microorganisms in finished product to encourage plant life.

1.6 BREATHING

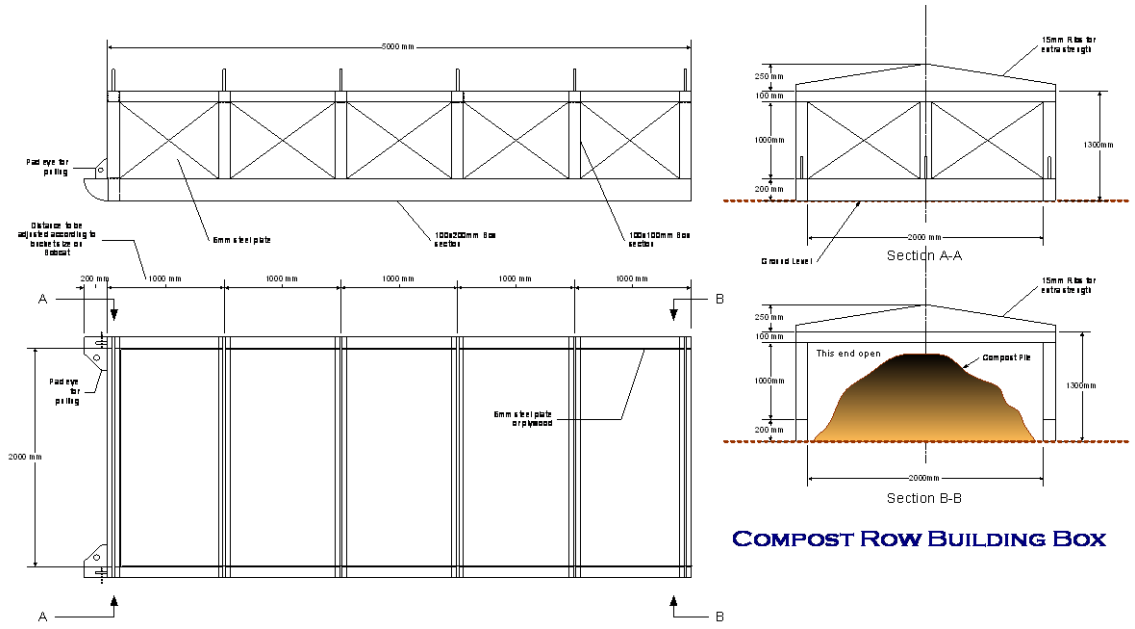
Aeration is neither "agitation" nor the mere exposing of the material to the ambient air inside the windrow as roto-tiller or flat paddle type turners do. The ambient air in the windrow can be full of carbon dioxide released from inside the pile and short on much needed Oxygen. Like breathing into a paper bag. The essence of successful turning/aeration is to force (and retain) fresh breathable air into all the waste material, and to completely "disrupt," "reshape" and "restack" the row. This action thoroughly exchanges the material in all three Zones creating an entire row with the characteristics of Zone # 2. The Windrow Dynamics will, over time, reform the three Zones. Therefore, proper timing of the turns will lead to a reduced in size in both Zone # 1 and Zone # 3.

1.7 CONSISTENCY

When a baker is baking a cake from scratch he does not simply add all the material in a bowl and not mix it then expect the cake to turn out OK. Instead the baker stirs and kneads the dough into a blended consistency. His primary purpose for stirring is to THOROUGHLY mix all the ingredients, eliminate chunks and insure consistency to complete the activity of the ingredients. The finished product, the cake, will be as good as the ingredients and how well they

are blended. No matter how you cut it, being able to produce consistent, mature compost with little or no odors *does not happen by accident* but is an organized and planned activity using a row-turner as is illustrated in the photos.

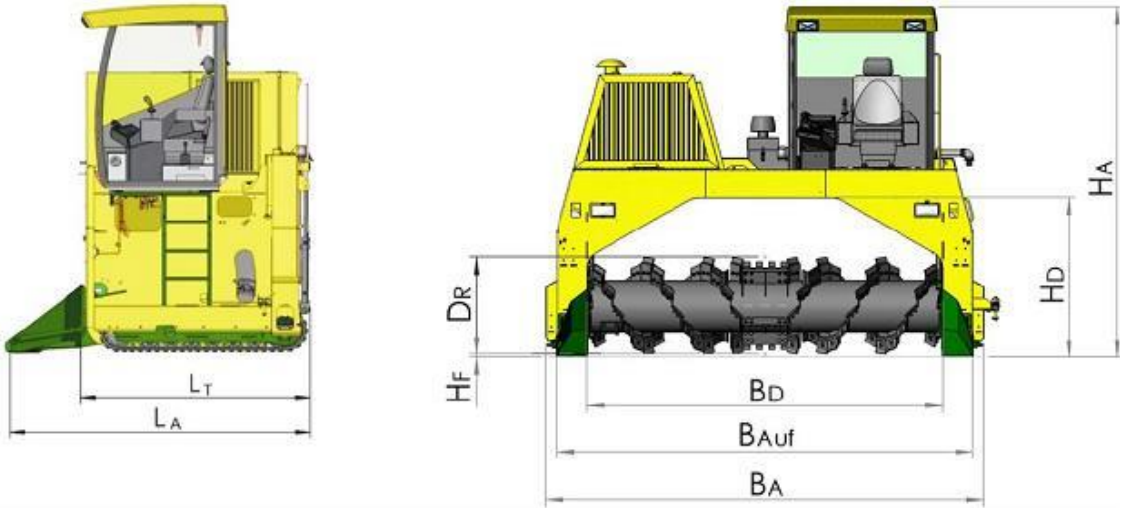
2 BOX FOR BUILDING ROWS



Under the United States Environmental Protection Agency (USEPA) and European Union (EU) Environmental Authority “LANDFARMING” is no longer allowed. The only exception is where the land has already been polluted, for example “existing” oily waste dump sites then this area can be landfarmed, meaning treatment can take place in-situ directly on the soil.

The law therefore states no newly created oily waste can be dumped onto clean, unpolluted land and landfarmed (ploughed into the soil). Instead today treatment is only allowed and must be done on the “land surface” whereby the treatment site is prepared by laying down an HDPE liner covered with a 15 cm sand layer. On this prepared site it is allowed to build surface rows of waste and carry out row turning in a bioremediation operations. All material volumes in-and-out must be recorded.

3 GENERAL DRAWING OF A COMPOST ROW TURNER



The most critical feature of microbial bioremediation is a free and abundant supply of oxygen required to sustain microbe life and to allow for mass reproduction of the microbes. To accomplish this Mechanical Aerators are used to induce oxygen into the rows. Therefore, at minimum each row must be turned daily. Daily turning insures that solids and soil waste containing any volume of oil (so long as the oil is bound and retained in the solids and is not free flowing) can be decomposed down to <1.0% oil-on-solids/soils in a 4 to 6 month timeframe. If less than once-a-day row turning is done the decomposition timeframe will extend. If more than once-a-day turning is done, for example turning up to 2 to 4 times daily the decomposition timeframe can be lowered down to the 2 to 4 month timeframe.

Our experience using bioremediation declassification of oily waste is that, properly treated and managed, it is not the starting volume of oil in the waste that determines the treatment period but the supply of food available (food here defined as oil-hydrocarbon). For example solids waste containing 40% oil compared to solids waste containing 10% oil will both decompose down to <1.0% in the same timeframe. However as hydrocarbon is the food source in the process, once the oil content reaches 1% then the process slows since the food source is now minimized whereby the microbes must compete for this smaller source. Therefore the microbe population becomes depleted as the source of food becomes scarcer, thereby prolonging hydrocarbon decomposition of the last 1% oil residue. However oil is 100% biodegradable and in time this final 1% oil will fully decompose - at the end the process does not stop, even once the rows are no longer turned. It then is only time related, which can add from 2 to 6 months longer. For example the Dutch oil-on-solids regulation is <10 ppm and this is achieved over a period of one year, however 10 ppm is the most stringent in the world owing to the fact that the Netherlands is mostly below sea level with a high annual rainfall.

4 BIOREMEDIATION IN OPERATIONS

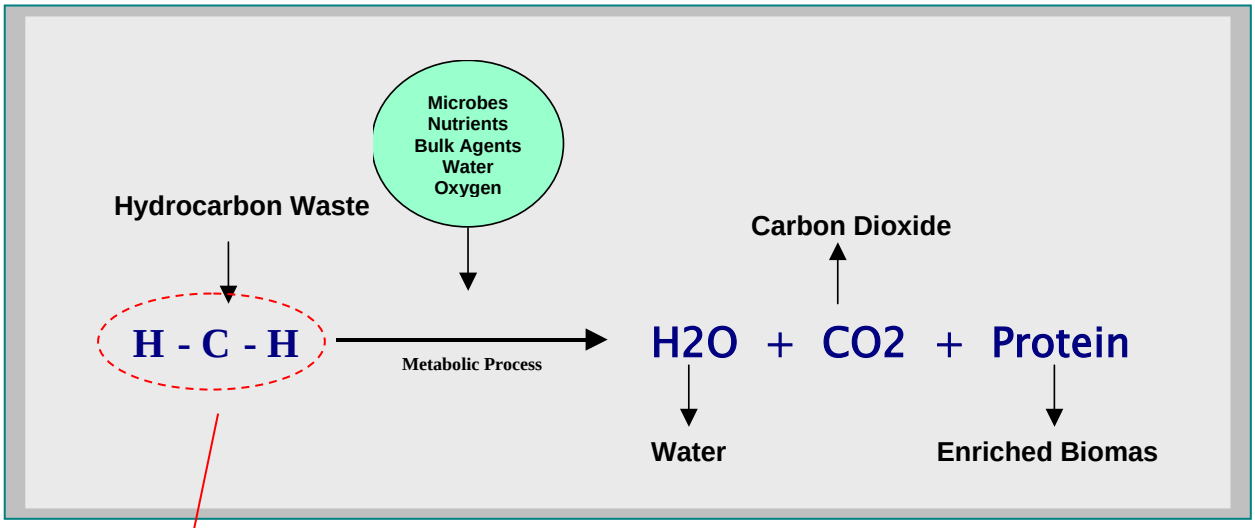
Method Fully Complies with Environmental Audits

Materials are:

- Measured into rows for environmental recordkeeping
- Each row is bench tested for treatment applications
- Each row is treated with bulk agents and nutrients
- Each row is tested monthly for hydrocarbon decomposition
- Each row undergoes final testing once reaching "Declassification"
- Declassified materials are graded for Environmental Classification:
    - Agriculture Grade Biosolid
    - Stabilized, if containing heavy metals, as a fill material
    - Disposed of from site according to their classification

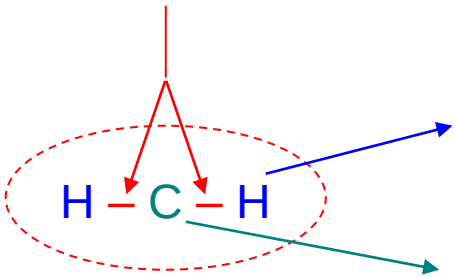
5 THE BIOREMEDIATION PROCESS

The Metabolic Process of Bioremediation



Hydrocarbon is the **Microbe Food Source** by ingestion they **break the H & C bonds**

Hydrocarbon consist of simple to complex bonds of Hydrogen and Carbon



2 H ions + 1 O ion = H_2O

1 C ion + 2 O ions = CO_2

Microbes die & become Protein Biomass