World Journal of Environmental Biosciences
Available online at:
www.environmentaljournals.org Volume 1, Issue 1: 55-73

Open Access | Research Article

Aerobic Sponge Method Vermitechnology (ASMV) for Distillery Effluents of Molasses-based Alcohol Industries

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Abstract:

One of the technology transfers from ECO-BELT R&D PVT. LTD., is Aerobic Sponge Method Vermitechnology (ASMV) for distillery effluents of molasses based alcohol distilleries in India. The ASMV technology has been approved and recommended by the State and Central Pollution Control Board, India, for the conversion of total quantity of distillery effluent let out/annum (after bio-methanation) in six distilleries in India, keeping in mind the general guidelines (protocols) of KSPCB (State) & CPCB (Central). In the current paper the same technology has been detailed as done in one of the distillery (KAPCHEM DISTILLERIES, Mysore District, Karnataka, India) wherein, a direct macro-level research and development with successful utilization of the total let out effluents (62,500 M3/day) on regular basis under 250 operative days/annum on continuous basis has been shown. The complete activities were operated as Phase – I and Phase – II. Effluent consumption on to the biosolids in a period of 250 operative days/annum was divided into 2 cycles as cycle – I and cycle II with each cycle comprising of 125 days each. In Phase – I operation biosolids of agro-industrial wastes of pressmud (as nitrogenous source) from cane industries and cocopith (as ligno-cellulosic base) from coir industries were used in 1:1 proportion of 12,000tons/annum (with 70% moisture) that were distributed with 300 tons/ Aerobic Organic Sponge Bed (AOSB) and 20 such AOSBs with a size of 190 ft. X 45 ft. (8,850 sq.ft.) could consume 12.5 M3 of effluent X 20 AOSBs X 125days X 2 cycles = 62,500M3 of total distillery effluent let out. The activity of effluent spraying took place in a year on continual basis covering all thro' the seasons of rainy, winter and summer – a typical agro-climatic pattern of Southern India. In Phase – II operation, the effluent soaked AOSBs of 20 numbers (of 125 days effluents @ 31,250M3) were shifted to 10 vermisheds (with impervious concrete floor) for aerobic degradation of 2-3 weeks of water stabilization with the maintenance of av. 60% moisture in the effluent soaked biosolids prior to vermiprocesses for procurement of vermicompost – which is devoid of distillery effluent characteristics to commercialize the same as value added product. The mode of Phase – I and Phase - II operations have been explicitly documented in the current paper with authenticity and proven a mark of 'zero discharge' statement of consentment from P.C.Bs (State and Central).

Keywords: biosolids, caromel-burnt sugar, compost earthworms; cocopith, modified vermicomposting, nitrogenous Pressmud, physico-chemical nutritive status.

1.0 Introduction:

Molasses based alcohol industries that run throughout the year in India are the prime revenue generators for the State governments but face statuatory demands for the disposal of distillery effluents from SPCB (State), CPCB (Central) and EIA (Central). Presently the existing technologies applicable for the distillery effluents are – equalization, neutralization, oxidation ponds, solar ponds, trickling filters, aerators, clarifiers, ion exchange, reverse osmosis, thermal reduction, air stripping, biomethanation, chemical precipitation and composting. Several workers have attempted the conversion and utilization of distillery effluents as compost and vermicompost under laboratory, pilot scales and have transferred the technologies as composting and vermicomposting. Distillery wastes as organic debris that can be utilized for microbial degradation both aerobic and anaerobic method are acceptable and their utility thro' these means are a possibility (Chandra et al, 2002; Jain et al, 2002; Chandra et al, 2005; Jain et al, 2005; Sowmeyan and Swaminathan, 2007; Tewar et al, 2007). Conversion of distillery sludge with other bulky organic wastes are a possibility; however utilization and/or disposal of distillery effluents that is let out on an annual basis with an av. 450M3/day is enormous either before treatment or after bio-methanation processes (**see table: 1**)and as on date at least 420 units are in operation in India that struggle to dispose off the treated distillery effluents as per the Norms of SPCB, CPCB and EIA. The authors with their more than a decade research and development in the field of distillery effluents have implemented their indigenous, state-of-the-art ASMV technology for distillery effluents in six distilleries in India. The work encompasses the conversion of liquid-state-distillery effluents into solid-state-vermicompost by the creation of aerobic sponge beds of estimated quantities of biosolids of pressmud and cocopith keeping in mind the SPCB (state) and CPCB (central) Rules and regulations. Implementation of vermiprocesses for bulk conversions of agro-industiral wastes (solid/liquid/slurry) is a prerequisite tool for the study of bioenergetics of compost earthworm under three seasons of rainy, winter and summer of typical Indian agro-climatics (DST, 1997; Sunitha, 2001; 2011c, 2012c and 2012e) is a mandatory issue. Utilization of nitrogenous wastes and ligno-cellulosic wastes to improve bio-geo-chemcial cycle in the soils as humus building; for an act of enzymatic interactions within the soils; in the physiology of plant cells - as nutrient uptake, providing resistance, enhancing tolerance through the action of humates within the integrated plant systems are some of the stepping stones that have been proven via compost earthworms' vermicompost thro' vermiprocesses (Parmelle and Crossley, 1988; Chaudhuri et al, 2000; canellas et al, 2002; Atiyeh, 2002; Yagi and Ferreira, 2003; Sinha et al, 2005; Mann, 2005; Arancon et al, 2006; Quiao et al, 2006; Carlos et al, 2008; Gopal et al, 2010; Kavitha et al, 2011; Dobbss et al, web search; Edwards et al, web search). Bulky pressmud utilizations has shown ways and means as vermicomposting under laboratory conditions that gave way for commercialization (Kale et al, 1993; Kale et al, 1994; Kale, 1998a; 1998b; Lakshmi and Vizayalakshmi, 2000; Sunitha, 2001; 2012d). cocopith of lignin and cellulose based waste was a problematic nearly three decades ago is now developed as value addition in its conversion, its efficiency as absorption-adsorption of leachate of wet garbage, an efficient material in the nurseries of India (Kale et al, 1994; Sunitha, 2011a; 2011b; 2012a; 2012b; 2012d). Consumption and assimilation; casting; physiology; metabolism (respiratory); energy budget; growth; temperature; moisture; cold tolerance; rainfall; pH; Oxygen; water; C:N ratio are the influencing and the mandatory tools utilized to know the efficiency of compost earthworms in harnessing vermicompost for business perspectives and in the abatement of anthropogenic organic pollution (Neuhauser et al, 1980; Picci et al, 1986; Holmstmp et al, 1990; Butt, 1991; Daniel, 1991; Rivet, 1991; Hallett et al, 1992; Viljoen et al, 1992; Reddy et al, 1993; Hallett , 1994; Muyima et al, 1994; Ma et al, 1995; Dominguez et al, 1997; DST, 1997; Fayolle et al, 1997; Koojiman, 2000; Uvarov and Scheu, 2004; Hou et al, 2005; Bisht et al, 2006). In the current research paper, an efficient use of distillery effluents with biosolids of pressmud and cocopith (**see Figs. 1a and 1b**) has been made use of in the indigenous state-of-the-art ASMV technology based on nature's simple laws of evaporation techniques by creating natural vent processes without any mechanical aerators in the Phase – I operation through estimated quantities of biosolids and calculated levels of distillery effluents. In Phase – II operative processes a simple stabilization process with water for 2-3 weeks was carried out and followed by vermiprocesses has been shown thro' ASMV technology making way to cottage industry within the distillery premises and the same has been illustrated as here.

2.0 Materials and Methods:

The characterization of the distillery effluents (**Table: 1**) were carried out frequently after the bio-methanation process that was permitted to utilize for the said ASMV technology by the KSPCB and CPCB. Aspects like geological, climatic, hydrological and biological parameters were taken into consideration prior to the implementation of the technology (**Table: 2**). Rainfall details for successive three years was recorded (**Chart: 1**), based on the details the storm water storage tanks were calculated (**Estimate: 1**) and as per the **Estimate 1**, the outlay plan for the rainwater and the operative design for ASMV technology (of Phase – I and II) was prepared (**Plan: 1)** and accordingly established. **Table: 3** shows the simple, scientific procedure behind the ASMV technology. Required land for the Phase – I and II operation to consume the total effluent let out (62,500M3) in 250 operative days were established as per the **Estimate: 2** and **Estimate: 3.** Procurement of required biosolids of pressmud and cocopith was done as per the calculations as in **Estimate: 4** for the 250 operative days/annum. Conversion of the effluent soaked biosolids as per the **Estimate: 5** was carried out. As the ASMV technology is the method of cottage industry that was operated within the distillery premises, the economics of the project was done as shown in **Estimate: 6** and accordingly the business was taken up to prove sustainability and zero-discharge as demanded by the KSPCB and CPCB. The formation of AOSBs (20 Nos.) for Phase – I and vermisheds (10 Nos.) for Phase – II was done as shown in **Plate: 1** for the consumption of 62,500 M3 of effluent in 250 days at the rate of 250M3/day. Each AOSB of 190ft X 45ft (8,850sq.ft) was done as per the impervious protocol demanded by the KSPCB and CPCB which is also state-of-the-art of low-cost nature with high durability estimated to be av. 30yrs. The details of the work has been enumerated in **Plate: 2.** The enlarged section of the AOSB with the drain (for rain water flow) showing 100% safety of unpercolation of the effluent to the ground was the proof of the indigenous technology shown in **Plates: 3 and 4**. The single design of the AOSB as shown in **Plate: 5** is the bird view that could hold 1:1 proportion of pressmud and cocopith of 300tons with av. 65% moisture acted as macro-sieve of aerobic sponge bed (**Plate: 6**) of 2ft height with the surface formation of **'U'** curvature for the spongy compactness of the bed (**Fig: 2a**) for an act of absorption-adsorption of effluent solids leaving behind the moisture for evaporation (**Fig: 2b**) with the arrest of B.O.D. and C.O.D. without odor menace by the aerobic actions. During rainy seasons, before the onset of rains, each of the AOSBs were covered over by 250 G.S.M. of HDPE polysheets manually (**Plate: 7**), the sheets were laid in such a way over the surface and the sides of the sheets were drawn into the storm water drain to get rid off the rain water poured over the surface area of the AOSB (**Fig: 3**). The stipulated quantity of the effluents were sprayed after the stoppage of rains on to the AOSBs (**Fig: 4**). Phase – II operative processes of conversion of effluent soaked AOSBs taken for vermiprocesses are shown in **Fig: 5.** **Plate: 8** depicts the details that were laid as per the strict order of KSPCB and CPCB to prove imperviousness.

3.0 Results and Discussion:

1a

1b

Fig: 1a and 1b Organic biosolids of sugar factory pressmud and coir industry Cocopith

2a

6

2b

Fig: 2a and 2b Formation of AOSB (aerobic organic sponge bed with press mud and cocopith) and the view of after effluent consumption

Fig 3 : Use of HDPE sheets (250G.S.M) over the AOSB before the onset of rains during rainy season

Fig 4: Stipulated quantity of effluent consumption after the rains

Fig 5: Pictoral representations of Phase – II operations of ASMV technology

Table 1: Characteristics of distillery effluents

Parameters (mg/l)	Range
pH	4.32 – 7.48
Ash	28,340 – 40,000
Total Solids	65,000 – 99,810
C.O.D.	90,000 – 1,30,400
B.O.D.	50,000 – 70,825
Ammonical Nitrogen	75 – 150
Nitrogen	0.550 – 1831
Phosphorus	50 – 87
Potassium	570 – 8740
Sulfate	2,025 – 4,000
Calcium	840 – 1650
Magnesium	300 – 1342
Chlorides	350 – 5000
Sodium	248 - 270

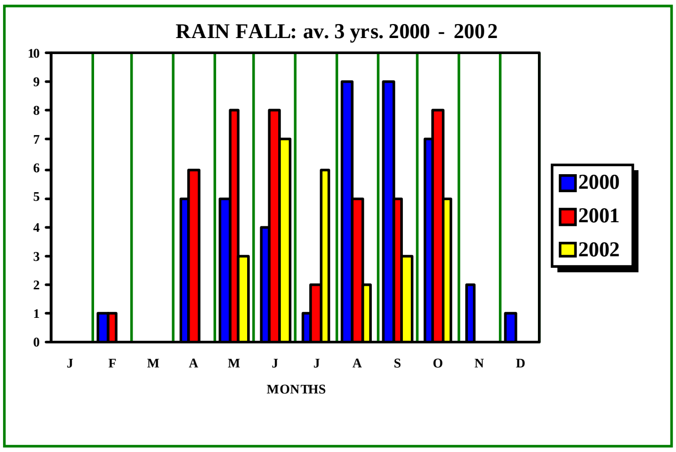


Chart 1: Rainfall details during the year 2000-02 (an av. Details of 3 successive years) Courtesy: Dept. of Hydrology, Mysore District, Karnataka State.

Table 2: Aspects taken into consideration prior to the implementation of ASMV TECHNOLOGY

Aspects	Details
Geological parameters	Land selection, formation of solid earth floor, dhumsed zero-zero ground.
Climatic parameters	Indian agro-climatic seasons of rainy, winter and summer; wind blow, air quality, humidity and temperature.
Hydrological parameters	Groundwater table, spentwash evaporation, effluent spraying onto the AOSBs.
Biological parameters	Biosolids nutritive status, aerobic decomposition, stabilization, vermiprocesses

Table 3: Simple, scientific procedure behind ASMV technology for distillery effluents

Procedure behind Phase – I operation	Procedure behind Phase – II operation
1:1 ratio of pressmud and cocopith admixed over impervious HDPE lined zero-levelled ground as CPCB & SPCB Norms. The layered biosolids form and act as a typical sponge-like with enmeshed network formation for aerobic activity. Such a bed is AOSB [Aerobic Organic Sponge Bed] an area 190' X 45' to consume 12.5M3 of effluent every day upto 125 days.	Aerobic organic Sponge Bed[AOSB] with its effluent quantity of 12.5M3 X 125 days =1,562.5M3 as organic biosolids will be shifted to cement concreted vermisheds for the conversion into vermicompost. Thus the final product is the completely digested & excreted humus-rich organic manure as vermicompost on losing its original effluent characters.

Table 4: What makes distillery effluent highly organic constituents that fit in for vermiprocesses

Organic content	Large amounts of organic and inorganic contents being in a liquid media cause B.O.D and C.O.D. that further add to the strong odor usually anerobic conditions due to liquid form. Nutrients such as nitrogen, phosphorus and potassium are the added advantage. Such effluents cause on entering into land (chokes the soil porosity due to impairment of microbial degradation) and eutrophication (excess growth of the floral communities) in the water bodies leading to land and water pollution respectively. however by implementation of ASMV the problematic effluent by loosing its characteristics gets transformed into value added vermicompost.
Acidity	pH of 3.8 – 4.4 corrodes the receiving impervious tanks and pipes and encourages acidic bacteria. By implementation of ASMV technology the acidic factors change into neutrality by the action of air penetration and due to aerobic microbial interactions.

Table 5: Problematic parameters of the effluent, stipulated Norms of P.C.B. and the bio-remediation through ASMV technology

Parameters	Distillery effluent (after bio-methanation)	P.C.B stipulated Norms	Effect of ASMV technology
Color	Persistent dark brown color	Colorless	The colour due to caromel being carbohydrate in nature, by the earthworm – microbial enzymatic action of carbohydrases gets degraded in the earthworm intestinal system.
Odor	Obnoxious odor	Odorless	Since the whole operational process is aerobic, the odour menace is not created.
B.O.D., C.O.D., T.S.S.	Av. 2,000 mg/l Av. 6,500 mg/l Av. 4,500 mg/l	> 100 mg/l	These 3 parameters are the indicators of the organic substrates, that get transformed into vermicompost as humic substance that forms the plant nutrient store house.
pH	Av. 7.5	Neutral	Through the action of fungal, microbial and earthworms' buffering action the end product vermicompost turns to neutral pH range.

Table 6: ASMV technology in accordance with the norms of the KSPCB and CPCB

Characters	KSPCB & CPCB Norms	ASMV technology
Generated effluents	To be collected, treated and disposed safely.	As per the rules and instead of disposal converted into value-added vermicompost
Effluent storage method	Shall make the lagoons and tanks impervious	Such establishments are done wherever ASMV is implemented
Bio-methanation digesters	Scientifically 100% operative to generate methane gas to save on furnace oil and to reduce the concentration of the effluent	Although ASMV works best for the effluents of direct from the plant but from the point of revenue demands effluents after the bio-methanation.
Yeast sludge separation	On to the impervious tanks to be treated and disposed	Taken for Phase – II operations that are carried out on impervious concrete floors.
Incineration installation	A condition wherein environmentally sensitive areas	No need of incineration that still generate toxic wastes and gases and are exhorbitantly high cost when operating ASMV technology.
Treatment as inorganic and organic effluent	Demands separate treatment for disposal	Both organic and inorganic effluents are taken for Phase – I operation and in Phase – II the effluents' inorganic and organic nature becomes stable humic substances of plant nutrient status.
disposal	Prohibition on to land and water prior to practical treatment	The distillery effluents transformed into solid, stabilized vermicompost with devoid of effluent characters.
Taken as composting	1. Near by sugar mills for pressmud and bagasse. 2. Land availability 3. Ground water table at the composting site not too high. 4. Land availability not in the nearby habitated area. 5. Proper disposal of the compost. 6. Necessary certificates to be submitted from the agricultural university. 7. disposal as per the university specifications.	1. Effective costing even procurement of biosolids are in a radius of 300KM and the effluent consumption happen in Cycle – I and II of 125 days each accounting to 250 operative days of the distillery and threshing season of the sugarmills in mind. 2. < 10acres for an av. 450M3 of effluent generation per day. 3. Establishments of Phase – I and II at the highlands higher to the ground water table. 4. Less than 10 acres is the required area for Phase – I and II thus establishments happen within the distillery. 5. The demand of vermicomposted distillery effluents is too high at a rate of Rs. 3,500/ton and can be kept for any months which is stablilized and would have lost the effluent characters with stabilized levels of total and available plant nutrients. 6. The product can be easily certified by the agricultural university and utilized for all crops.

Table 7: Nutrient status of the vermicomposted distillery effluents

Parameters	Range
	Major nutrients (in %)
Total Nitrogen	2.33 – 3.36
Available Nitrogen	0.0569– 0.0766
Total Phosphorus	0.97 – 1.40
Available Phsophorus	0.66 – 1.61
Total potassium	0.79 – 1.52
Available potassium	0.41 – 1.61
	Mega nutrients (in %)
Total Calcium	1.76 – 2.31
Available Calcium	1.10 – 1.32
Total Magnesium	0.40 – 0.74
Available Magnesium	0.20 – 0.40
Total Sulfur	0.28 – 0.36
Available Sulfur	80 – 780
Total Sodium	0.14 – 0.16
Available Sodium	0.13 – 0.16
	Micronutrients
Total Zinc	135 – 274
Available Zinc	37.02 – 38.14
Total Manganese	340 – 1459
Available Manganese	159.0 – 162.4
Total Copper	38.60 – 135.72
Available Copper	10.75 – 36.76
Total Iron	1992 – 6891
Available Iron	202.44 – 206.85
	Other details
pH	7.01 – 8.02
T.S.S.	0.72 – 0.0.91
Bulk density (g/cc)	0.65 – 0.73
Moisture in %	40 – 50
Organic Matter in %	13.50 – 16.50
Organic Carbon in %	7.50 – 9.10
C : N ratio	10:1 – 18:1

Existing methods and methodologies as vermitechnology manuals, guidelines, technologies and on-going research at world level (Neuhauser, 1988; Reinecke, 1992; Haug, 1993; Gaur and Sadasivam, 1993; Datar et al, 1997; Edwards, 1998; Liu, 2000; Lotzof, 2000; UNSW, 2002a; 2002b; Dominguez, 2004; Dynes, 2004; Sogbesan and Ugwumba, 2006; Meenatchi et al, 2007; Munroe, 2007; Nair et al, 2007; Sutar and Singh, 2008; Sinha, 2009; Patnaik and Reddy 2009; Karmegam et al, 2010; Juorez et al, 2011; Sunitha 2011a; 2011b; 2011d) addresses the compost earthworms' turnover role in the bio-degradation of man-made organic pollution and its end use as replenishments for productive soils, plants and as soil amelioration is applauding. During the biodegradation the role of bacteria and fungal effectiveness on distillery effluents is an indication that the distillery effluents are organic in nature and during the alcohol production no such chemicals are incorporated (Jain et al, 2002; Friedrich, 2003; Ghosh et al, 2004; Gupta et al, web search, Verma et al, 2011). The present ASMV technology is the relevance of the establishment of microbial degradation that happen during the Phase – I and in continuation with the Phase – II operation proven that the effluents' problematic characteristics of B. O.D., C.O.D., T.S.S., pH, color and odor gets transformed into solids of organic matter under the natural vent processes created in the AOSBs by the presence of biosolids of pressmud and cocopith (**Table: 4 and 5**).

Estimation 1: Details on storm water estimates in and around the working site and the requirement of storage tanks

The total area alloted for the Phase – I and Phase – II operation:

A] 505 X450 ft = 2,27,250 sq.ft.
B] 468 X 682 ft = 3,19, 176 sq.ft
Total area = 5,46,426 sq.ft.

Each size of AOSB 190 ft X 45ft = 8,550 sq,ft. Therefore total area of 20 AOSB = 1,71,000 sq.ft. Total area of the working site = 5,46,426 sq.ft. – total area of AOSB = 1,71,000 sq.ft.

The average rain fall per year 0.16 ft X 3,75,426 sq. ft = 60,068.16 cu. ft ----[a]
The total AOSB area = 1,71,000 sq.ft. X 0.16 ft = 27,360 cu.ft -----------------[b]

The summation [a] and [b] gives:
The total storm water collection in a month = 87,428.16 cu.ft..
Therefore, the storm water collection per day = 2,914 cu.ft.
On conversion, 2,914 cu.ft X 25lt. = 72,850 lt per day.
Hence, the required tank for storm water collection is = 1,000cu.ft X 3nos.

Estimate 2: Details on required land for the operations of Phase – I of ASMV technology
1) Land Requirement for Phase – I (Effluent consumption):
a) 300 ton of nitrogenous and lignocellulosic biosolids in 1:1 proportion before processing (with av. 67% moisture) occupies 190' X 45' ft as 1AOSB = 8,550 sq.ft.

Therefore, to accommodate 6,000 tons of biosolids for 20 AOSB, to consume 125 days effluent the needed area shall be 190' X 45' ft X 20 nos. = 1, 71,000 sq.ft.

b) Processing cycle is for 125 days. Therefore we shall divide our working days by the processing days. That is, 250 days / 125 days. Thus, each area usage = 2times in 250 days.

c) The required area for storm water drain cum garland canal and for vehicle movement. For this, we need to addan additional width of 10 ft. = 45,000 sq.ft.

The total land requirement for the effluent activity = 5.5 acres[2,16,000 sq.ft.]

Estimate 3: Details on required land for the operations of Phase – II of ASMV technology
On decomposition, 300 tons of 1AOSB biosolids gets reduced to 220 tons of biosolids (inclusive of 40 tons of effluent solids), the required area for 1 vermished for vermi processes is 100'X 25' **= 2,500 sq.ft.**
Therefore, to accommodate 4,400 tons of 20 AOSB biosolids need 10 vermisheds and the required land area is 100' X 25' X 10 nos. **= 25,000 sq.ft.**
b)Required area for tractor movement, earthworm sorting, sieving and packing and for other activities. For this, we need to add an additional width of 10 ft. **= 45,000 sq.ft.**
Therefore the area needed for vermi processes is = 1.5 acres (60,000 sq.ft.)

Estimate 4: Biomass requirement for ASMV technology calculated for 250 working days/annum

a) Required quantity of **nitrogenous biosolids** (pressmud/sewage sludge / pomace) and **ligno-cellulosic biosolids** to consume (cocopith / sawdust / leaf litter/ jute waste / bagasse / paper- mill sluge) in **1:1 proportion** to consume 250 days effluent that is 62,500 M3 (250 M3 per day) **= 12,000 tons**

b) The effluent consumption is for 125 days. Thus required biosolids is 6,000 tons. This forms for the **first cycle** of operation. After this the biosolids with effluent is taken to vermi processes. For the rest of next 125 days of effluent consumption we require again 6,ooo tons of biosolids. Hence procurement of biosolids and the process begins as **second cycle** of operation = **1st cycle and 2nd cycle = 250 days**

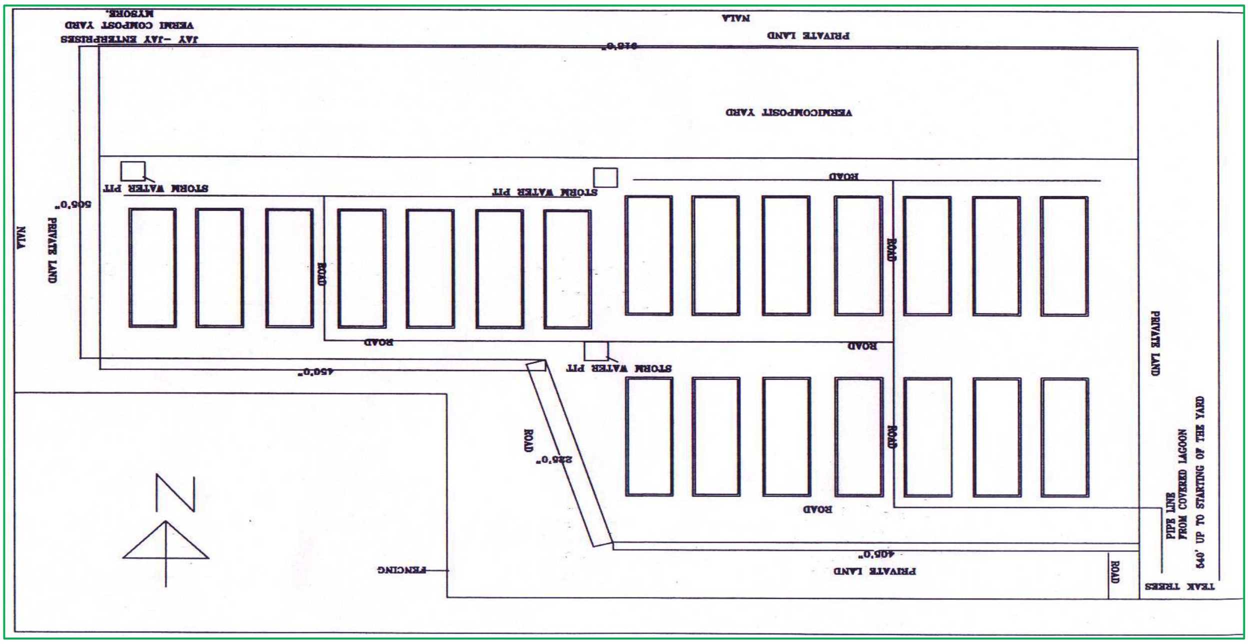
c) 1st cycle (begin from August to January) and 2nd cycle (February to July) works out to be 180 dayseach totaling to 360days; the first 30days in each of cycle 1 and 2 are kept for biosolid procurement, formations of AOSBs and establishment of pipelines. Similarly the last 25 days of each cycle will be used up for shifting of effluent soaked biosoilds for phase – II operations.

Estimate 5: Conversion of biosolids with effluents into vermicompost
The biosolids of nitrogenous and ligno-cellulosic in 1:1 proportion used up for effluent consumption in a period of 180 days tend to lose 40% of the total material. Further, during the vermi processes these materials again lose another 50% by weight.
Based on these aspect, the procured biosolids of 300 tons for 1 AOSB on consumption of effluent with its solids (40 tons) added, end up with 180 tons.

- This material of 180 tons on vermicomposting processess in 60 days duration like:
  - inoculation of earthworms and microbial symbionts,
  - feeding and excreting activities,
  - worm biomass establishment,
  - removal of vermicomposted material,
  - earthworm sorting,
  - drying under shade,
  - sieving and stacking / or packing, gives about 110 tons of the final product - vermicompost that is ready for sale. For the total 12,000 tons of biosolids, the expected quantity of vermicompost will be 4,800 tons.

Estimate 6: Economics of the project cost for the implementation of ASMV technology (The calculations carried out are based on certain assumptions, which will change on case to case basis. The costing worked out is only indicative)

(a)	**CAPITAL COST (In Lacks):**		
(1)	Land development cost [inclusive of land leveling, mud bund formation, storm water drainage / garland canal formation, HDPE poly sheet laying at the base with sand laying and HDPE poly sheet to cover over during rains]	Rs. 9.46	
(2)	Service charges of all possibilities	Rs. 2.00	
(3)	Effluent distribution system during Phase – I period and water requirement during Phase – II period [like pumps, pipes and other accessories]	Rs. 4.00	
(4)	Biosolid procurement of 12,000 tons at Rs. 300 / ton	Rs. 36.00	
		TOTAL	**Rs. 49.00**
(b)	**OPERATING COST PER DAY [In Rupees]:**		
(1)	Labours 10 Numbers, @ Rs. 60/-	Rs. 600.00	
(2)	Technical supervisor	Rs. 150.00	
(3)	Electricity	Rs. 500.00	
		TOTAL	**Rs.1,250.00**
(c)	**COST OF PRODUCTION [In Lacs]:**		
(1)	Assuming 250 days working days	Rs. 3.12	
(2)	Depreciation @ 25% of capital cost	Rs. 3.85	
(3)	Interest @ 16% on capital cost	Rs. 2.46	
(d)	**TOTAL READY VERMICOMPOST IS 4,800 TONS AS 45% RECOVERY. THUS, TOTAL COST OF VERMICOMPOST PER TON IS 49.40 / 4,800 TONS**		**Rs. 1,030.00**
(e)	**TOTAL PROJECT COST FOR FIRST YEAR (Capital cost and Production cost)**		**Rs. 58.83 Lacs**
(f)	**PROFITABILITY [as 100% sales] & THE TOTAL RECEIPT Assuming sale price of vermicompost per ton is Rs. 1,500.00 and the total vermicompost sold is 4,800 tons.**		**Rs. 72.00 Lacs.**
(g)	**PROFIT IN THE FIRST YEAR**		**Rs. 13.17 Lacs.**



Plan 1: Based on the Estimate: 1 the outlay plan for the rain water and the operative design for Phase – I and phase – II operations of ASMV technology

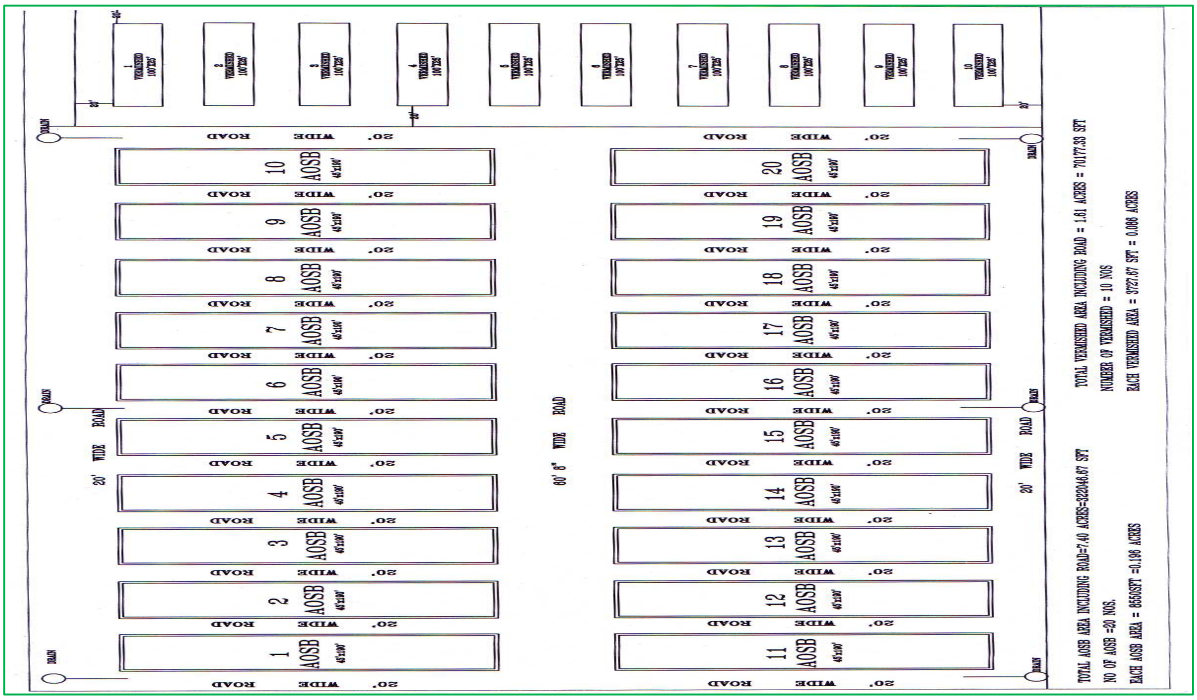


Plate 1: The overall view of the land area allotted for effluent consumption (phase – I operation) and vermicomposting area (phase – 2 operation). 20 nos. of AOSBs and 10 nos. of vermisheds are required for the consumption of 62,500 M3 of effluent in 250 days at the rate of 250 M3 per day.

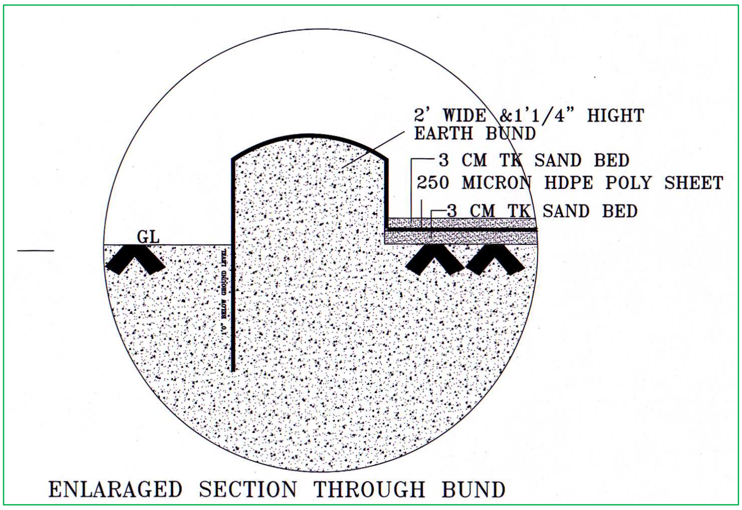


Plate 2: The allotted area for effluent consumption per AOSB is 190 ft. X 45 ft. (8,850 sq.ft.) is first leveled to zero – zero ground. A mud bund of 2 ft wide and 1¼ ft height is formed. The surface area will be covered with 3c.m. thick sand bed and over it 250 G.S.M. poly sheet of HDPE quality will be laid in such a way that the sheet overlaps the mud bund and enters 1 ft. inside the ground. Then over the surface area of the sheet another 3 c.m. thick sand bed is laid.

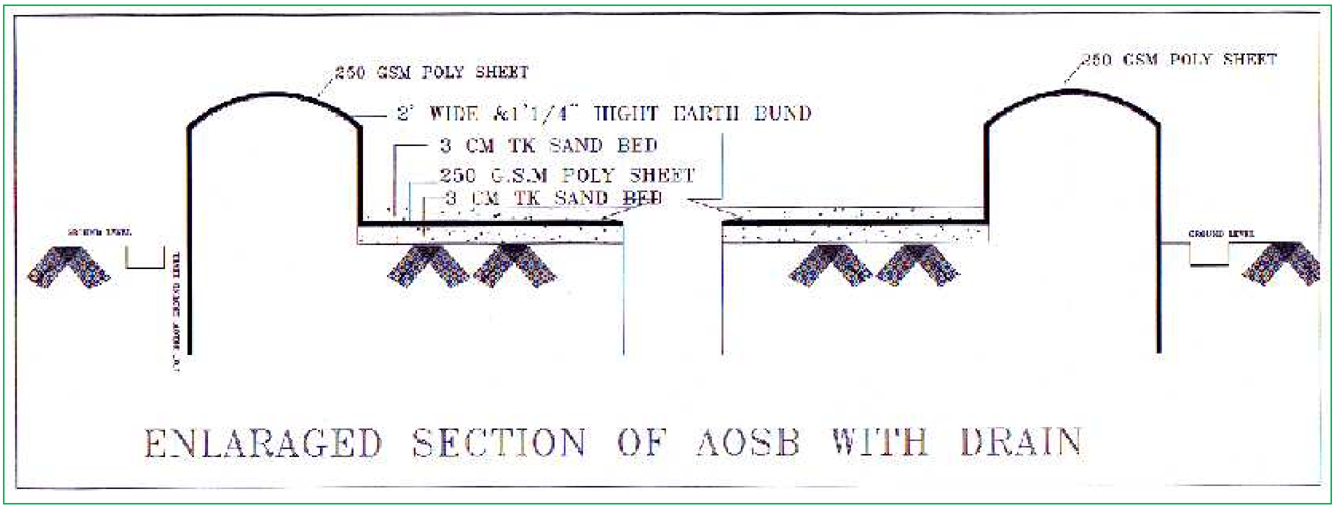


Plate 3: The entire sponge area and its surrounding area with the mud bund and its surroundings below the ground will be made 100% safety against effluent seepage and percolation into the soil beneath it.

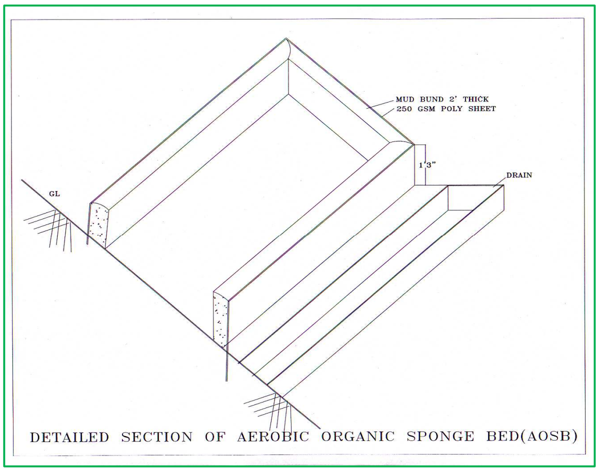


Plate 4: Next to the mud bund area of each AOSB is, established with permanent storm water drain cum garland canal.

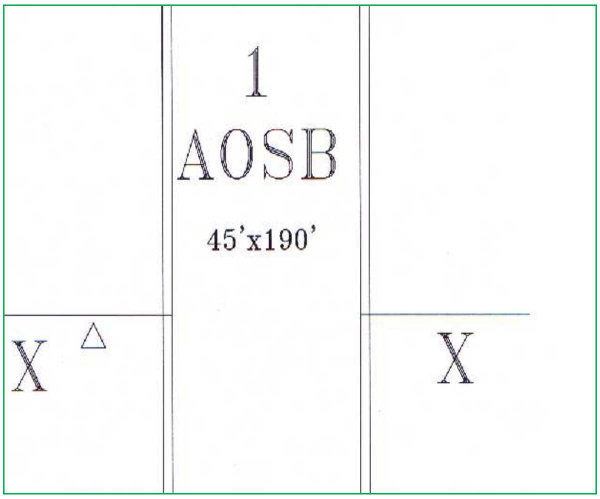


Plate 5: 1:1 proportions of nitrogenous biosolids like pressmud and lignocellulosic biosolids like cocopith of 300 tons with 60-75% moisture are layered on (well prepared 100% safty area against effluent seepage and percolation) an area of 190 ft. X 45 ft. (8,850 sq.ft.)

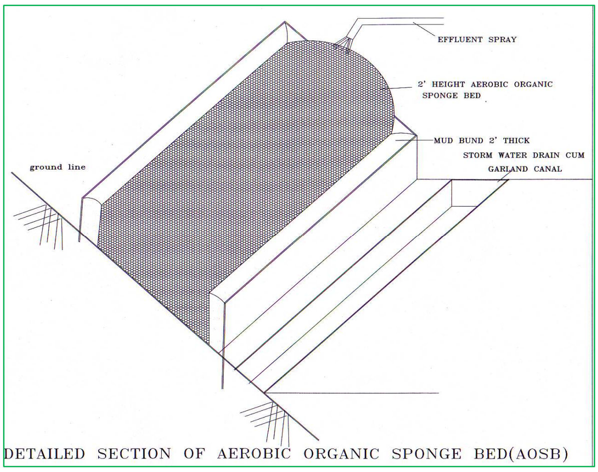


Plate 6: This area with biosolids is created up to 2 ft height as a sponge bed with a semi 'U' shaped curvature on top, hence the name Aerobic Organic Sponge Bed (shortly, AOSB).

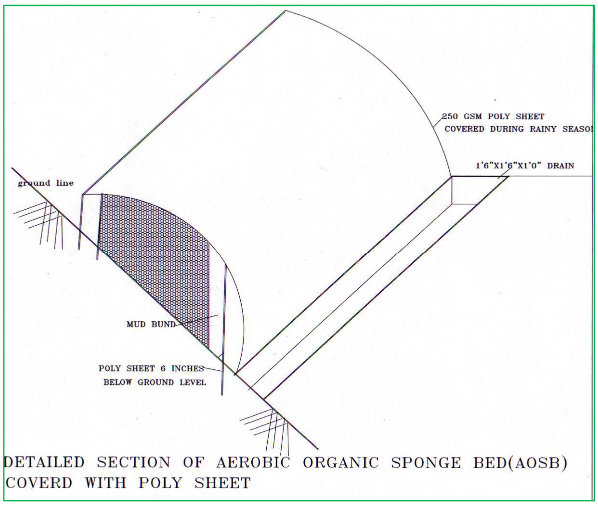


Plate 7: During rainy seasons, the AOSBs are covered over by 250 G.S.M. poly sheets of H.D.P.E. quality. The sheet will be laid on overall surface and at the sides in such way that the sheet enters the storm water drain to get rid off the rainwater poured over the surface area of the AOSBs.

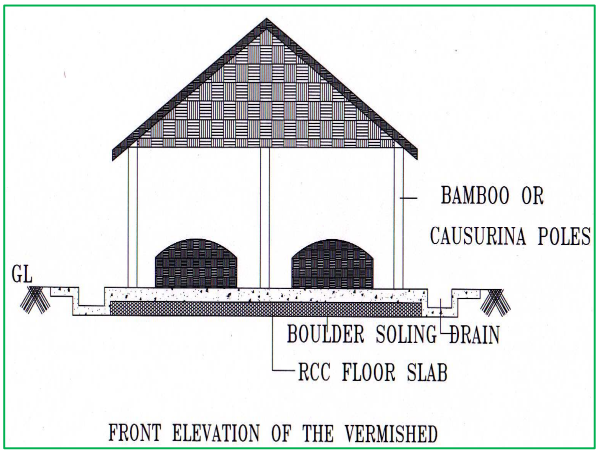


Plate 8: On completion of the first 125 days of effluent consumption cycle, the 20 nos. of AOSBs are shifted to 10 nos. of vermisheds. Each vermished is of 100 ft. X 25 ft. = 2,500 sq.ft. The vermished is made permanent with boulder soling and RCC floor slabs to enable tractor movement and to avoid any water seepage into the ground beneath it. The area is protected by thatched roofing supported by bamboo or causurina poles to provide safer activity for earthworms as well as to save the effluent biosolids against rain, sun and wind.

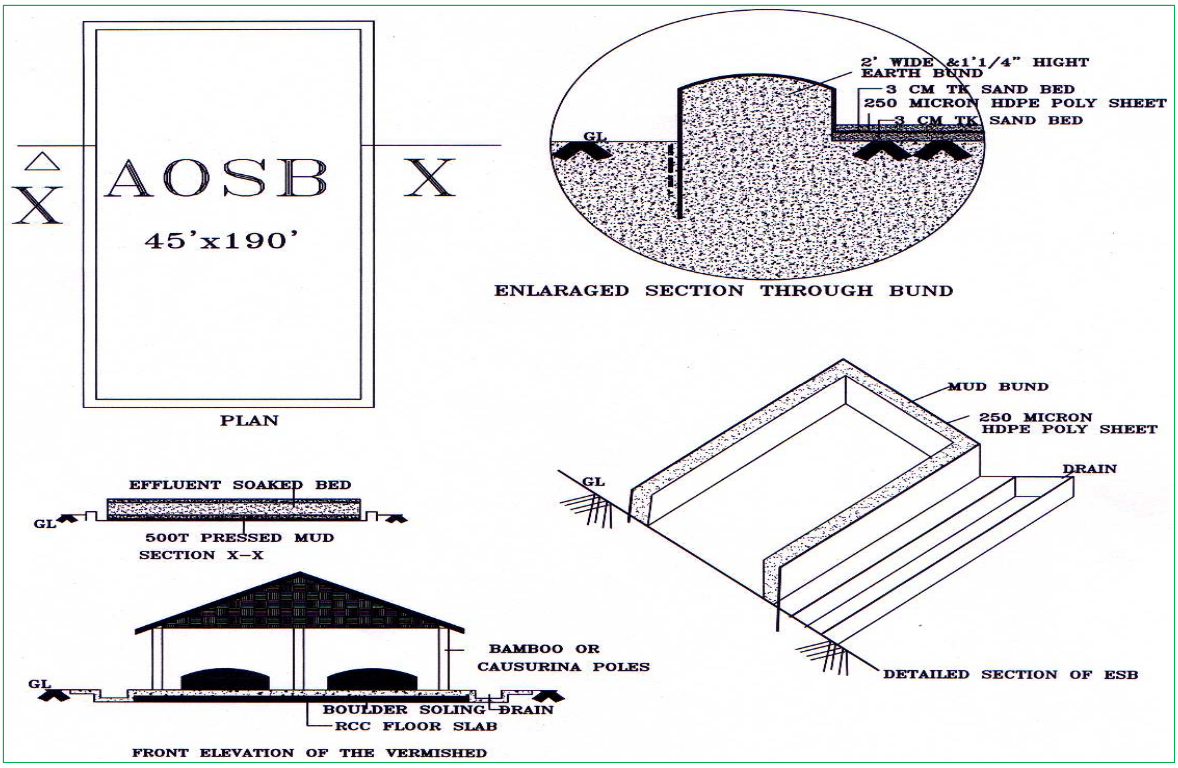


Plate 9: Schematic representations of Phase – I and II of ASMV technology

Utilization of distillery effluents after biomethanation is a prerequisite for methane generation to save on furnace oil for the boilers. Consideration of the utilization of distillery effluents after biomethanation as liquid fertilizer has been a recent trend in some of the distilleries in India and enormous research in this line is high (Kumar et al, 2000; Bhaskar et al, 2003; Kaushik et al, 2006; Singh et al, 2007; Pant and Sharma, 2010; Malaviya and Sharma, 2010; Rath et al, 2010; Karnam and Joshi, 2010; Chauhan and Rai, 2010; Alka et al, 2011). Caromel (melanoidins) – burnt sugar of thick syrup with 1.35 Optical Density and is soluble in water but insoluble in Benzene is the unacceptable coloration that remain in the receiving waterbodies and SPCB as well as CPCB objects for this. Caromels are nothing but complex large carbohydrates reduced in size to acids, comparable to roasted coffee/broiled and/or grilled meat. Attempts have been made for the color removal (Adholeya, 2007; Chandra et al, 2008; Jiranuntipn et al, 2009; Rajasundari and Murugesan, 2010). In the present novel ASMV technology the problem of caromel does not arrive (**Table: 6**) as the breakdown of the melanoidins may take place in the earthworm gut by the association of gut flora and/or enzymes; which can be observed as the absence of color when vermicompost is left in water media however a straw-color decantation are obtained as in the case of any general vermicompost proposed as vermiwash and/or verm tea (Meenatchi et al, 2011; Radovich, 2011). ASMV technology is based on simple scientific justification for the evaporation of distillery effluents' moisture into the atmosphere leaving behind the solids that bind/coagulate to the pressmud and cocopith that is in accordance to nature's fundamental truth which can be summerized as:

- Aerobic Organic Sponge Bed [AOSB] is an aerobically evaporating process facilitated by nature as that of the natural evaporation cycles observed in the oceans.
- Aerobic Organic Sponge Bed [AOSB] resembles that of bird's & animal's lungs in an act of release of aerobic gases.
- Aerobic Organic Sponge Bed [AOSB] bring up the effluents' moisture for surface evaporation through an act of surface tension as in the case of roots of trees. The research findings have proven that the distillery effluents is nothing but highly conc. Organic base biochemical byproducts that can be successfully changed into organic vermicompost (**Table: 7**). Higher the BOD and COD, richer the quality of vermicompost in terms of balanced plant nutrients.

3.0 Conclusion:

Distilleries in India face a problem by the State and Central Pollution Control Board (CPCB)s directions of zero-effluent discharge. It demands incineration and concentration techniques like the developed countries; which are not the bioremediation for an agrarian country like India. Instead, the present indigenous state-of-the-art ASMV technology is a better option from the point of total effluent utilization within the distillery by consuming onto another set of disposable bulky wastes of pressmud and cocopith for the transformation into solid state and there after to follow vermiprocesses. Thus distillery effluents' problematic B.O.D., C.O.D., T.S.S., caromel color and abnoxious odor - changes into organic nutrients thro' Phase – I and II operative methodology of ASMV technology (**Plate: 9**) which does not demand mechanization and the beauty of this technology is that it can be operated with few labours. The whole operation continues in all agro-climatic conditions. The ASMV technology not only march towards zero pollution but become a revenue generating cottage industry within the distillery to show zero effluent discharge and to help to enrich our agricultural soils that is dearth of humic substances.

4.0 Acknowledgment:

The authors acknowledge the officials of the KSPCB – Simha (Chief Envtl. Officer), Nanda Kumar (Senior Envtl. Officer), Dr Niranjan (Envtl Officer), Prakash(Envtl. Officer); the officials of the CPCB, Suresh (Regional Envtl. Officer) and Mahalakshmi, Envtl. Officer; Distillers – Timme Gowda, Chamundi Distilleries; Narayanaswamy, J.P. Distilleries; H.K. Bhandari, AABL, Madhya Pradesh; Sunil Kapoor, Kapchem Distilleries; Govindappa Shetty, Gauri Distilleries; and Dasappa, Wilson Distilleries.

6.0 References:

1) Adholeya A. (2007). Enhanced production of ligninolytic enzymes and decolorization of molasses distillery wastewater by fungi under solid state. Biodegradation, 18 (5): 647-659.
2) Alka S, Swapanil Y and Sharma M.K. (2011). Studies on treatment of distillery effluent and effect of different composts on seed germination. Trends in Biosciences, Vol. 4, Issue:1, 66-67.
3) Arancon N. Q, Edwards C.A, Lee S and Byrne R. (2006). Effects of humic acids from vermicomposts on plant growth. European J. Soil Biology 42: S65-S69.
4) Atiyeh R.M, Lee S, Edwards C.A, Arancon N.Q and Metzger J.D. (2002). The influence of humic acids derived from earthworm-processed organic wastes on plant growth. Bioresource Technology 84: 7-14.
5) Baskar M, Kayalvizhi C, Bose M and Chandra S. (2003). Eco-friendly utilization of distillery effluent in agriculture – a Review. Agril. Reviews, Vol. 24, Issue 1, 16-30.
6) Bisht, R, Pandey H, Bisht S.P.S, Kandapal B and Kaushal B.R. (2006). Feeding and casting activities of the earthworm (Octolasian tyrtaeum) and their effects on crop growth under laboratory conditions. Tropical Ecology 47 (2): 291-294. ISSN 0564-3295

7) Butt, K.R., (1991). The effects of temperature on the intensive production of *Lumbricus terrestris* (Oligochaeta: Lumbricidae). *Pedobiologia,* 35 : 257-264.
8) Canellas L.P, Olovares F.L, Facanha A.L.O and Facanha A.R. (2002). Humic acids isolated from earthworm compost enhance root elongation, lateral root emergence and plasma membrane H+ ATPase activity in maize roots. Plant Physiology, Vol. 130 no. 4 1951-1957.
9) Carlos G. R, Denooven L and Antonio G.M.F. (2008). Vermicomposting leachate (worm tea) as liquid fertilizer for maize (Zea mays L.) forage production. Asian J. of Plant Sci., 7(4): 360-367.
10) Chandra S, Joshi H.C, Pathak H, Jain M.C and Kalra N. (2002). Effect of potassium salts and distillery effluent on carbon mineralization in soil. Bioresource Technol. 83 (2002) 255-257.
11) Chandra S, Joshi H.C and Pathak H. (2005). Impact of distillery effluent and salts on hydraulic conductivity of a sandy loam soil. Caspian J. Envt. Sci., Vol. 3 No.1 ppX-Y.
12) Chandra et al, (2008). Melanoidins as major colorant in sugarcane molasses based distillery effluent and its degradation.
13) Chaudhuri P.S, Pal T.K, Bhattacharjee G and Dey S.K. (2000). Chemical changes during vermicomposting (Perionyx excavatus) of kitchen wastes. tropical Ecology 41 (1): 107-110.
14) Chaudhari L.B. and Murthy Z.V.P. (2009). Treatment of distillery spent wash by combined UF and RO processes Global Nest Journal, Vol. 11, No.2, 235-240.
15) Chauhan J and Rai J.P.N. (2010). Monitoring of impact of ferti-irrigation by post methanated distillery effluent on groundwater quality. Clean-Soil, Air, Water, Vol. 38, Issue 7, 630-638
16) Daniel 0. (1991). Leaf-litter consumption and assimilation by juveniles of Lunbricus terrestris L. (Oligochaeta, Lumbricidae) under different environmental conditions. Biol Fertil Soils, 12 : 202-208.
17) Doninguez J, Briones M.J.I and Mato S. (1997). Effect of the diet on growth and reproduction of Eisenia Andrei (Oligochaeta, Lumbricidae). Pedobiologia 41, 566-576, Gustav Fischer Verlag Jena.
18) Datar, M.T., M.N. Rao and S. Reddy (1997). Vermicomposting: A Technological Option for Solid Waste Management. J. of Solid Waste Technology and Management, 24 (2): 89-93.
19) Dobbss L.B, Canellas L.P, Olivares F. L, Aguiar N. O, Peres L.E.P, AZevedo M, Spaccini R, Piccolo A and Faanha A.R. (Web search). Bioactiivity of chemically transformed humic matter from vermicompost on plant root growth. Journal of Agriculture and food chemistry. (accessed dt: 01/01/2012).
20) Dominguez J. (2004). State of the art and new perspectives on vermicomposting research. Earthworm Ecology, 2nd edn. ©2004 by CRC Press LLC
21) Edwards C.A. (1998). The use of earthworms in the breakdown and management of organic wastes. In: Edwards, C.A. (Ed.), Earthworm Ecology. CRC Press, Boca Raton, FL, pp. 327±354.
22) Department of Science and Technology Research Project Report. (1997). Biodiversify of soil organisms and bioenergetics of earthworm population in natural *and* interfered ecosystems. Institute of Research in Soil Biology and Biotechnology, Chennai, India. 98 pp.
23) Dynes R.A. (2003). EARTHWORMS, Technology Info to Enable the Development of Earthworm Production, Rural Industries Research and Development Corporation (RIRDC), Govt. of Australia, Canberra, ACT.
24) Edwards C.A, Arancon N.Q, Kai T. C and Ellery D. (Web search). The conversion of organic wastes into vermicomposts and vermicompost teas which promote plant growth and suppress pests and diseases. (accessed dt. 01/01/2012).
25) Fayolle L, Michaud H, Cluzeau, D, Stawiecki, J. (1997). Influence of temperature and food source on the life cycle of the earthworm *Dendrobaena veneta* (Oligochaeta). Soil Biol. Biochem. 29, 747–750. Janssen, P.M., Bergema, W.
26) Friedrich J (2003). Bioconversion of distillery waste. Fungal biotechnology in agricultural, food and envtl. Appli. (ed. Arora D.K., Bridge P.D and Bhatnagar D. CRC Press. Print ISBN: 978-0-8247-4770-1
27) Gaur A.C. and Sadasivam K.V. (1993). Theory and practical considerations of composting organic wastes. In: *Organics in soil health and crop production* (Thampan,P.K., ed), Peekay Tree Crops Development Foundation, Cochin, India. pp: 1-22.
28) Ghosh A.K, Singh B, Bose N and Tiwari K.K. (2004). Biocomposting of distillery waste to control water pollution. Ocean 2003 Proceedings, 1194-1198. Vol.3, San Diego, CA.

Digital Object Identifier: 10.1109/OCEANS.2003.178018

29) Gopal M, Gupta A, Palaniswami C, Dhanapal R and Thomas G.V. (2010). Coconut leaf vermieash: a bio-liquid from coconut leaf vermicompost for improving the crop production capacities of soil. Current Science, Vol. 98, No.9.
30) Gupta, Kumar S, Gupta S.K and Singh G. (Web search). Biodegradation of distillery spent wash in anaerobic hybrid reactor. Water Research 41: 721-730. (accessed dt: 16.07/2011).
31) Hallett L, Viljoen S.A. and Reinecke A.J. (1992). Moisture requirements in the life cycle of *Perionyx excavatus* (Oligochaeta). *Soil Biol Biochem,* 24 : 1333-1340.
32) Haug R.T. (1993). The practical handbook of compost engineering, pp. 248. Lewis Publishers. A CRC press company.
33) Holmstrup M, Hansen, B.T. Nielsin A. and Dstergaard LK. (1990). Frost tolerance of lumbricid earthworm cocoons. *Pedobiologia,* 34 : 361-366.
34) Holmstmp M. (1994). Physiology of cold hardiness in cocoons of five earthworm taxa(Lumbricidae: Oligochaeta). J *Comp Physiol B,* 164 : 222-228.
35) Hou J, Qian Y, Liu G and R. Dong. (2005). "The Influence of Temperature, pH and C/N Ratio on the Growth and Survival of Earthworms in Municipal Solid Waste" Agricultural Engineering International: the CIGR Ejournal. Manuscript FP 04 014. Vol. VII. November, 2005.
36) Jain N, Minocha A.K and Verma C.L. (2002). Degradation of predigested distillery effluent by isolated bacterial strains. Indian J Exp. Biol. 40(1): 101-5.
37) Jain N, Bhatia A, Kaushik R, Kumar S, Joshi H.C. and Pathak H. (2005). Impact of post-methanation distillery effluent irrigation on groundwater quality. Envtl. Monitoring and Assessment, 110 (1-3): 243-255.
38) Jiranuntipon S, Delia M, Albasi C and Damronglerd S. (2009). Decolourization of molasses based distillery wastewater using a bacterial consortium. Science Asia 35 (2009): 332-339.
39) Juarez P.D.A, Fuente J. L, Paulin R. V. (2011). Vermicomposting as a prcess to stabilize organic waste and sewage sludge as an application for soil. Tropical and Subtropical Agroecosystems 14: 949-963.
40) Kale R.D, S.N. Seenappa and J. Rao. (1993). Sugar factory refuse for the production of vermicompost and worm biomass. V International Symposium on Earthworms; Ohio University, USA.
41) Kale R. D, Bano, K, Sunitha, N. S And Gangadhar, H. S., 1994, Adhoc scheme on promotion of vermicomposting for production of organic fertilizers (sponsored by ICAR, New Delhi*). Consolidated Tech. Rep., Uni. Agric. Sci. Bangalore (India)*.
42) Kale R.D. (1998a). Earthworm Cinderella of Organic Farming. Prism Book Pvt Ltd, Bangalore, India.
43) Kale R.D. (1998b). Earthworms: Nature's Gift for Utilization of Organic Wastes. In C.A. Edward (Ed.). 'Earthworm Ecology'; St. Lucie Press, NY, ISBN 1-884015-74-376.
44) Kamegam N, Kale R.D, Daniel T.M, Alam N and Rodriguez M.G. (2010). Status, trends and advances in earthworm research and vermitechnology. Hindawi Publishing Corpn. Applied and Envtl. Soil Science. Vol. 2010, Article ID 962726, 2pgs.
45) Karnam P.V and Joshi H.C. (2010). Application of distillery effluents to agricultural land: is it a win-win option for soils and environment. In: 19^{th} World congress of Soil Science, Soil Solutions for a Changing World, 1-6 Aug. 2010, Brisbene, Australia.
46) Kaushik R, Prasanna R and Joshi H.C. (2006). Utilization of anaerobically digested distillery effluent for the production of Spirulina platensis. J. Sci. & Industrial Res. 65(June), 521-525.
47) Kavitha P, Ravikumar G and Manivannan S. (2011). Microbial population and humic acid content in the vermicompost of the earthworm, *Eudrilus eugeniae* (Kinb) reared in banana agro wastes. Global J. of Envt. Res. 5(2): 53-56, 2011.
48) Kooijman S.A.L.M. (2000). Dynamic Energy and Mass Budgets in Biological Systems. Cambridge University Press, Cambridge, p. 424.
49) KSPCB (Web Search). Norms for treatment and disposal of effluents from distilleries. (accessed dt. 10/06/2011).
50) Kumar U, Joshi H.C, Jain M.C and Singh S.K. (2000). Effect of post methanation distillery effluent on yield of wheat crop and fertility status of soils. J. Bio-Energy 1(2): 123-127.
51) Lakshmi B.L. and G.S. Vizaylakshmi (2000). Vermicomposting of Sugar Factory Filter

Pressmud Using African Earthworms Species (Eudrillus eugeniae). Journal of Pollution Research, 19 (3): 481-483.
52) Liu Y.L. (2000). The technology and condition of indoor earthworm cultivating. Microbiology Journal. 20(3): 63-64.
53) Lotzof M (2000). Vermiculture: An Australian Technology Success Story. Waste Management Magazine, February 2000, Australia.
54) Ma W.C, Khalil M.A, Donker M.H, Van S. N.M. (1995). Long-term and short-term changes in the energy budget of *Porcellio scaber* Latreille (Crustacea) exposed to cadmium in polluted food. Eur. J. Soil Biol. 31, 163–172.
55) Malaviya P and Sharma A. (2010). Impact of distillery effluent on germination behaviour of Brassica napus L. J. Envtl. Biology 32(1) 91-94. Bioresource Technology, Vol. 99, Issue 11, 4648-4660.
56) Mann R.K.S. (2005). Response of kharif groundnut (Arachis hypogaea) to planting patterns and row application of organics. Thesis submitted to Univ. Agril Sci., Dharwad.
57) Meenatchi R, Giraddi R.S, Patil V.S, Vastrad A.S and Biradar D.P. (2011). Effect of vermitechnologies on jasmine insect pests. Karnataka J. Agric. Sci., 24(3): 312-315.
58) Munroe G. (2007). Manual of On-farm Vermicomposting and Vermiculture; Pub. of Organic Agriculture Centre of Canada, pp: 39.
59) Muyima N.Y. O, Reinecke A.J and Viljoen S.A. (1994). Moisture requirements of Dendrobaena veneta (Oligochaeta), a candidate for vermicomposting. Soil Biol. Biochem 26: 973-976.
60) Nair J, Kuruvilla M and Goen, Ho, (2007). Earthworms and composting worms-Basics towards composting applications. Paper at 'Water for All Life-A Decentralised Infrastructure for a Sustainable Future'; March 12-14, 2007, Marriott Waterfront Hotel, Baltimore, USA.
61) Neuhauser E.F, Hartenstein R and Kaplan D.I. (1980). Growth of the earthworm Eisenia fetida in relation to population density and food rationing. Oikos, 35, 93-98.
62) Neuhauser E.F, Loehr R.C and Malecki M.R. (1988). The potential of earthworms for managing sewage sludge. In : Edwards C.A. and Neuhauser E.F. (eds.). Earthworms in waste and environmental management. SPB Academic Publ. BV, The Hague, 9-20.
63) Pant D and Adholeya A. (2009). Nitrogen removal from biomethanated spentwash using hydroponic treatment followed by fungal decolorization. Envtl. Engg. Sci., 26(3): 559-565.
64) Parmelle R.W. and Jr. D.A. Crossley (1988). Earthworm Production and Role in the Nitrogen Cycle of a no-tillage agro-ecosystem on the Georgia Piedmont. Pedobiologia, 32: 353-361.
65) Patnaik S and Reddy M.V. (2010). Nutrient status of vermicompost of urban green waste processed by three earthworm species – Eisenia fetida, Eudrilus eugeniae and Perionyx excavatus. Appl. And Envt. Soil Sci. Vol. 2010, Article ID 967526, pp.13
66) Picci at el (1978) in Ferrari, G. (1986): Oxygen, water and temperature in the decomposition process of an organic substance during composting in compost: production, quality and use. In: Bertoldi, M. De, Ferranti, M.P., L'Hermite, P. & Zucconi, F. (eds). Proceedings of a symposium organized by the commission of the European communities, Directorate General Science, Research and Development, 17-19 April 1986.Udine Italy.
67) Qiao Y.Y., W. Li, G.J. Peng and R.J. Dong. (2003). Effect of earthworm in environment protection. *Innovation and Development of Pasturage Engineering*. China Agriculture Science Press. 205-211.
68) 68. Radovich T, Pant A, Hue N, Sugano J and Arancon N. (2011). Promoting plant growth with compost teas. Hanai Ai/The Food Provider. Web Search (accessed dt. 14/01/2012).
69) 69 Rajasundari K and Murugesan (2010). Decolourization of distillery waste water – role of microbes and their potential oxidative enzymes (Review). J. Appl. Envtl. Biol. Sci., 1(4) 54-68.
70) Rath P, Pradharn G and Mishra M.K. (2010) Effect of sugar factory distillery spent wash on the growth pattern of sugarcane crop. J. of Phytology, 2(5): 33-39. ISSN: 2075-6240
71) Reddy M.V. and Pasha, M. (1993). Influence of rainfall, temperature and some soil physicochemical variables on seasonal population structure and vertical distribution of earthwor~nsin two semi-and tropical grassland soils. *Inr JBiotech,* 37 : 19-26.
72) Reinecke A.J., S.A. Viljioen and R.J. Saayman (1992). The suitability of Eudrilus eugeniae, Perionyx excavatus and Eisenia fetida (Oligochaete) for vermicomposting in Southern

Africa in terms of their temperature requirements. J. of Soil Biology and Biochemistry, 24: 1295-1307.
73) Rivet-o-Hernandez. R. (1991). Influence of pH on the production of *Eisenia foerida. Avanc Alitnr~ltA tlim,* 31 : 215-217.
74) Singh K.K, Sharma S.K. and Sharma D.K. (2007). Effect of distillery effluent based pressmud compost alone and in combination with inorganic fertilizers on growth and productivity of basmati rice (Oryza sativa L). Int. J. Agric. Sci., 3(1): 107-109.
75) Sinha K. (2009). Earthworms vermicompost: a powerful crop nutrient over the conventional compost and protective soil conditioner. Am-Euras J. Agric and Environ Sci 5 (S): 01-55.
76) Sinha P.S, Nagin R, Singh B.D, Griyaghey U.P, Saratchandra B and Sinha B.R. R.P. (2005). Studies on the vermiculture technique and efficacy of vermicompost in substituting NPK and FYM requirements of Morus alba. Indian J. Agric Res. 39(4): 235-241.
77) Sogbesan A and Ugwumba A.A.A. (2006). Effect of different substrates on growth and productivity of Nigeria Semi-Arid Zone earthworm (Hypodrilus euryaulos, Clausen 1842) (Oligochaeta : Eudrilinae). World J. of Zoology 1 (2): 103-112.
78) Sowmeyan R and Swaminathan G. (2007). Retracted: Effluent treatment process in molasses based distillery industries: A Review. Journal of Hazardous Materials: Vol. 152, Issue 2, 453-462.
79) Sunitha N.S. (2001). Bioenergetics of tropical earthworm on exposure to domestic and industrial sludge. Thesis submitted and awarded from Jnana Bharathi, Bangalore University,Bangalore. India. Thesis awarded for Ph.D.degree.
80) Sunitha N.S. (2011a). Transformation of wet garbage of Indian urbanites at household level. UJERT, Vol. 1, Issue 2: 169-175.
81) Sunitha N.S. (2011b). Decomposable garbage as an anthropogenic factor and need for positive perspective: A review. UJERT, Vol.1, Issue 3: 253-267.
82) Sunitha N.S. (2011d). Effective Use of Cocopith for Faster Conversion of Sewage Sludge into Vermicompost. World Journal of Environmental Biosciences (WJEB). Paper accepted and issued in the month of January, 2012 (Manuscript No. WJEB 1101 January)
83) Sunitha N.S. (2011e). Experimental studies for growth and bioenergetics in Eudrilus eugeniae under three agro-climatic conditions of rainy, winter and summer. UJERT, (to be published, Manuscript No. 2011 411.pdf.)
84) Sunitha N.S. (2012a). Effective use of cocopith for faster conversion of sewage sludge into vermicompost. WJEB 1101 January issue.
85) Sunitha N.S. (2012b). Larm as a necessity during composting and/or vermicomposting of kitchen refuses. UJERT, 2102 February issue.
86) Sunitha N.S. (2012c). Influence of circadian rhythm on feeding and defecation in compost earthworm Eudrilus eugeniae. UJERT, 2101 February issue.
87) Sunitha N.S. (2012e). Seasonal effects on growth and bioenergetics of Eudrilus eugeniae (Kinb) using sugar factory pressmud (CSP) as feed substrate. World J. Environ. Biosciences, (accepted).
88) Sunitha N.S. (2012f). Chemical analyses of vermicomposted red pomace waste from a winery. World J. Appl. Envt. Chemistry, (accepted).
89) Sunitha N.S. (2012g). Feasibility studies for utilization of coal thermal flyash with compostable wastes based on physico-chemical parameters of the vermicomposts. World J. of Appl. Envt. Chemistry, (accepted).
90) Sutar S and Singh S. (2008). Vermicomposting of domestic waste by using two epigeic earthworms Perionyx excavatus and Perionyx sansibaricus. Int. J. Envt. Sci., Tech. 5 (1), 99-106.
91) Tewar P.K, Batra V.S. and Balakrishnan M. (2007). Water management initiatives in sugarcane molasses based distilleries in India. Resources Conservation and recycling: Vol. 52, Issue: 2, pp. 351-367.
92) UNSW, ROU, (2002a). Vermiculture in Organics Management-The Truth Revealed, (Seminar in March 2002) University of New South Wales Recycling Organics Unit, Sydney, NSW, Australia.
93) UNSW, ROU, (2002b). Best Practice Guidelines to Managing On-Site Vermiculture Technologies, University of New South Wales Recycling Organics Unit, Sydney, NSW, Australia; (Viewed in December 2004) www.resource.nsw.gov.au/data/Vermiculture%20BPG.pdf
94) Verma A.K, Raghukumar C and Naik C.G. (2011). A novel hybrid technology for remediation of

molasses-based raw effluents. Bioresource technology, Vol. 102 (3): 2411-2418.

95) Viljoen S.A, Reinecke A.J and Hartman L. (1992). The temperature requirements of the epigeic earthworm species Dendrobaena veneta (Oligochaeta) – a laboratory study. Soil Biol. Biochem. 24: 1341 – 1344.

96) Uvarov A.V, Scheu S. (2004). Effects of temperature regime on the respiratory activity of developmental stages of *Lumbricus rubellus* (Lumbricidae). Pedobiologia 48, 365– 371.

97) Yagi R and Ferreira M. E. (2003). Organic matter fractions and soil fertility under the influence of liming, vermicompost and cattle manure. Scientia Agricola Vol. 60, n.3, pp. 549-557.