

Miscellaneous

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PREPARATION OF COMPOST MANURE FROM TOWN WASTES

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PREPARATION OF COMPOST MANURE FROM TOWN WASTES

BY

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MANURIAL VALUE OF TOWN WASTES

THERE has been a rapid increase in the urban population of this country during the last 40 years counting in the term urban all those who live in units of over 2 000 population for purposes of

consideration of refuse disposal problems The variation in distribution among the different population units during the last four decades is shown by census figures given in Table I

TABLE I—Growth of urban population in India

Class	Head of unit	Population of unit	Total population living in the units in millions				
			1901	1911	1921	1931	1941
A	Cities	Above 100 000	6 30	7 05	8 05	9 04	15 04
B	Towns	5 000 to 100 000	25 35	25 75	28 91	36 46	42 39
C	Bigger villages	2 000 to 5 000	36 40	41 28	45 09	53 56	68 40
	Total of Groups A B and C		68 14	74 08	82 05	99 06	121 73
D	Smaller villages	1 000 to 2 000	54 26	62 26	64 30	73 71	79 30
E	Hamlets and unenumerated	Below 1 000	171 06	178 82	172 50	179 47	187 86
	Total population of India		294 30	315 16	318 04	352 84	388 80

In the above categories groups A to C live in bigger units managed by municipalities or village *panchayats* having sanitary staff for the collection of refuse in their respective areas The proportion of total population using household privies or public latrines decreases in the order of groups A > B > C the range varying from 90 per cent to 25 per cent The remaining percentage go into the fields or use the outskirts of the village for passing their excreta Villages in group D are managed by small village *panchayats* which generally do not maintain any sanitary staff for collection of refuse while the *panchayat* system is absent in group E The system of public latrines or private privies is practically absent in the villages coming under groups D and E Most of the human excreta is voided in the area surrounding the villages with attendant fouling of the air and streams Till the *panchayat* system with necessary sanitary staff for collection of refuse is established in such areas it is not possible to introduce sanitary methods of refuse disposal

But in the case of groups A B and C there already exists the necessary organization for the collection of refuse viz the municipalities and village *panchayats* It would be seen from figures given in Table I that our urban population has almost doubled itself during the last 40 years In 1941 the total of groups A B and C came to 121 73 millions At the present rate of increase our total urban population may be expected to reach 150 millions in 1951

Statistics collected at different municipal centres in India show that the output of urban refuse amounts to about $\frac{1}{3}$ to $\frac{1}{2}$ lb of *katchra* (street sweepings and dustbin refuse) and $\frac{1}{3}$ to $\frac{1}{2}$ lb of night soil per head of population per day There is con-

siderable variation from centre to centre depending on local factors such as industrial activity dilution of night soil with ablution water etc In general the quantity of dry refuse tends to be higher in the big units and in cities like Bombay it may go up to $1\frac{1}{2}$ lb per head per day The variation in night soil collected is mainly due to admixture with liquid constituents such as urine and ablution water In most areas the collection of urine is only partial most of it going into sullage along with ablution water

In addition to the two major groups of refuse noted above viz *katchra* and night soil there are others of lesser magnitude which assume importance in bigger cities e.g. cattle wastes slaughter house refuse sullage water sewage sludge etc In bigger cities where a large number of cattle chawls are being maintained in order to supply milk to the urban population the by products of cattle viz dung litter and urine often find their way to the municipal refuse depot especially in the monsoon season

India is maintaining over 300 million heads of live stock of which about 200 million are cattle and 70 to 80 million are goats and sheep If the mortality of the above animals be estimated at about 10 per cent per annum the animal wastes derived from the natural death or slaughtering of nearly 30 million animals per year $\frac{2}{3}$ of which are cattle would also be available for the preparation of manure The major portion of the above animals probably find their way to one of the slaughter houses maintained in every town and city

The total manurial value of the town wastes corresponding to an urban population of 120 millions (Groups A B and C in Table I) in India who possess already local organizations for the collection of their refuse is shown in Table II

PREPARATION OF COMPOST MANURE FROM TOWN WASTES

TABLE II—*Manurial value of urban wastes in India*

(Urban population 120 millions)

Per year	Dry matter	Nitrogen	Phosphoric acid (P O)	Potash (K O)	Calcium (CaO)
	Tons	Tons	Tons	Tons	Tons
<i>Katchra</i> (dry refuse)	12 000 000	96 000	36 000	240 000	600 000
Night-soil	1 750 000	105 000	52 500	26 000	44 000
Urine	2 000 000	850 000	50 000	70 000	100 000
Slaughter house wastes	250 000	25 000	10 000	2 500	7 500
Total	16 000 000	576 000	148 500	338 500	751 500

The figures presented in Table II show the huge quantity of manurial constituents present in our urban wastes enough to prepare over 1½ crores of tons every year of good quality agricultural manure containing over 2 per cent nitrogen and one per cent phosphoric acid and superior to ordinary farmyard manure

The present system of disposal of refuse practised in most municipal and *panchayat* areas aims more at fulfilling sanitary requirements rather than at any systematic utilization of the manurial value of the refuse. It may not be far amiss to say that at present less than 10 per cent of our total urban refuse is being converted into manure and sold for agricultural purposes. The rest of the refuse is dumped into pits or low lying areas or burnt away in brick kilns or in incinerators. The true significance of this waste is realized when one considers that the total manurial value of our urban refuse as given in Table II represents material that has been directly or indirectly removed from our agricultural area. In view of the rapid rate at which our urban population is increasing it would be suicidal for our agriculture to allow the drain shown in Table II to continue unchecked for another 50 or 100 years which would mean a rapid deterioration in the fertility level and productive capacity of our soils.

Most soils in India are deficient in organic matter. Our tropical temperatures lead to rapid destruction of the organic matter present in the soil. A sufficient supply of organic matter is necessary in soils in order to keep the soil in good physical and biological condition and thus to ensure healthy crop growth. Organic matter is of special importance in heavy clay soils (e.g. black cotton soils) in loose sandy loams (e.g. lateritic and red loams) and also in the case of saline and alkaline soils. As vast areas in India belong to one or other of the above groups the importance of adding to the land sufficient dosages of organic manures at regular intervals would become self evident.

Our present supply of farmyard manure is insufficient to meet our agricultural requirements on account of various factors such as the widely prevalent practice of using cattle dung and litter as fuel, almost complete wastage of cattle urine and crop residues and our defective method of preparation of farmyard manure. In view of this deficiency in farm manure the importance of urban wastes

as providing a valuable supplementary source for the preparation and supply of organic manure for agricultural purposes would become evident. This new source would become of increasing importance equalling and even exceeding in quantity farmyard manure in the future along with the progress of urbanization in this country.

PRESENT METHODS OF DISPOSAL

In the vast majority of municipal areas in this country the present methods of disposal of refuse are —

(a) *Katchra* (road sweepings and dustbin refuse) — These are dumped into low lying areas round about the town partly as a method of reclamation of such areas but mainly as an easy method of disposal of the dry refuse. A few centres have tried the method of incineration but as this involves heavy outlay and expenditure in addition to manipulative difficulties in the incinerator the method has not become popular with municipalities. In some localities the organic fraction of the *katchra* is purchased by brick kiln owners for use as fuel for brick kilns. There is little demand for *katchra* from agriculturists probably because it is poor in nitrogen and its wide C/N ratio acts adversely on crop growth by depressing available nitrogen in the soil.

(b) *Night soil* — The method of disposal adopted at most centres is the system of pitting or trenching wherein the night soil is deposited in pits or trenches to a thickness of 2 to 3 feet and covered over with a layer of *katchra* on top. There is plenty of smell and fly breeding associated with the system especially when the night soil starts anaerobic decomposition and liberates gases including hydrogen sulphide and skatolic bodies. On the windward side the smell evolved may create nuisance in the neighbourhood up to a distance of even a mile.

The trenching system is also known as the *poudrette* system since the material obtained from the above trenches after they become dry is known as *poudrette*. In addition to smell and fly breeding the *poudrette* system suffers from the following drawbacks —

(i) The difficulty with which the night soil gets dry. It generally takes about a year before the night soil becomes sufficiently dry to enable the resulting product to be sold as manure. If rains intervene the period of drying is considerably prolonged.

(ii) The poudrette method works out best on black cotton soils which possess good dehydrating power in summer time. In the case of *murum* soils with underlying rock the method fails since the drying is extremely slow. In the case of loose sandy soils there is danger of liquefied but undecomposed night soil percolating through the surrounding soil and contaminating neighbouring sources of drinking water especially in rainy weather.

(iii) The poudrette manure that is obtained as a result of the pitting or trenching system represents only partially decomposed material which still retains the disagreeable smell and other objectionable features of night soil. As such cultivators are averse to its purchase and use on their land. Special workmen belonging to the *bhangr* class have generally to be employed for transporting and spreading poudrette manure on land which means extra expenditure for the cultivator.

(iv) Cultivators have found from experience that poudrette manure reacts badly on the soil and on the crop. It is colloidal in nature alkaline in reaction and poor in organic matter and when applied in heavy doses deflocculates and spoils the physical condition of the soil to such an extent that there is complete failure of crops for several seasons. Being an unbalanced manure rich in nitrogen which pushes up vegetative growth in the early stages and depletes soil moisture rapidly the cultivators also complain that poudrette manure sometimes burns up the crop should late rains fail.

(v) The quantity of manure obtained by the poudrette system is small as compared to the bulk of night soil treated and the proceeds obtained by sale of poudrette manure are generally insufficient to meet the maintenance expenses of the night soil depot. Hence a depot working on the poudrette system is a source of recurring annual loss to the municipality.

(c) *Slaughter house wastes*—The slaughter house wastes consisting of blood waste meat liver intestines offal etc are in most cases thrown into pits and allowed to undergo putrefactive fermentation with the liberation of a great deal of highly disagreeable odours. No proper method is adopted for converting such wastes into useful manure. In a few centres blood is separately collected dried and sold as manure but this method is possible only where large size slaughter houses exist.

(d) *Sewage and sullage*—The number of towns and cities in India fitted up with the sewerage system forms a very small fraction of the total number probably such towns may not exceed 50 for the whole of India and in several cases the system covers only a portion of the municipal area. The sewerage system helps to carry off the night soil but in such centres the problem of disposal of *katchra* (dry refuse) still remains unsolved.

In the majority of centres the sewage is wasted by being let into the sea river or nalla (small valley or natural depression). There are however several towns e.g. Pona Ahmedabad Mysore Bangalore Lyallpur Hyderabad (Deccan) Nagpur Madura etc which utilize the sewage for irrigating agricultural land. This is a useful method by which the manurial

value of sewage could be returned to the land. At the same time the method has been found to bring in a decent revenue to the municipalities concerned. Various crops such as sugarcane grass *jowar* papaya vegetables and fruit trees have been successfully grown on land supplied with sewage giving heavy yields of crops and proportionately increased profits to the cultivator.

THE COMPOST SYSTEM

For some years now the system of compost making has been recommended as a satisfactory method of disposal of town wastes which would overcome the several drawbacks of the present methods adopted for the disposal of town refuse (*katchra*) and night soil. But the system of compost making has not become popular with municipalities so far since economic and sanitary factors were not fully taken into account in the methods of compost making till now recommended to municipalities.

As a result of special investigations carried out under the auspices of the Imperial Council of Agricultural Research at the Indian Institute of Science Bangalore the above economic sanitary and agricultural factors have been incorporated into an improved system of compost making which has been given an extensive trial at several municipal centres in the Bombay province with very encouraging results. Several of the municipalities have found the method of composting to be so satisfactory from the hygienic and economic aspects that they have adopted the process on a routine basis in order to deal with the whole of the daily output of refuse.

The advantages of the new system of compost making over the previous poudrette and other methods of disposal of refuse are—

(i) Instead of having separate methods of disposal of *katchra* (street and dustbin refuse) night soil slaughter house wastes and sullage the compost method provides a common system wherein all the wastes could be disposed of at the same spot and the same day they are collected.

(ii) The compost method provides a hygienic and highly sanitary method of disposal of refuse since the vigorous microbial activity and high temperatures (above 60 C) which are developed in the compost mass in a day or two and persist for some weeks serve effectively to destroy all elements of smell pathogenic organisms fly larvae weed seeds and obnoxious constituents present originally in town wastes.

(iii) The proportion of dry refuse (*katchra*) to the liquid portion (night soil or sullage) is so adjusted that the compost mass is solid enough to permit a man walking over it even on the first day the trench is filled up (cf poudrette system). On account of vigorous microbial decomposition and heat produced the mass decomposes very rapidly and at the end of four months a well decomposed innocuous product of high manurial value is obtained which has no smell and is superior to ordinary farmyard manure in respect of its contents of nitrogen and organic matter.

(iv) On account of the high percentage of organic matter present composts act similar to farmyard manure in improving the physical texture of heavy,

clayey soils as well as of sandy loams. They are specially beneficial on saline and alkaline soils. In all these respects composts are quite different from pourette manure.

(v) On account of the proper balance between organic matter, nitrogen and phosphorus contained in town refuse composts these act as well balanced manures in pushing up both vegetative activity in the early stages and grain formation in the later stages. Regular application of good quality compost manure is the best way of maintaining soil fertility at a high level over a long period of time.

(vi) Since compost making utilizes *katchra* slaughter house wastes and sullage in addition to night soil the total output of manure per year is much higher in the compost system than in the pourette system. If the improved system of compost making in trenches be adopted which cuts down labour charges to the minimum the margin of profit that would accrue to the municipality by undertaking the preparation and sale of compost manure from its town wastes is bound to be appreciable. The labour charges for compost making by the improved method come to about 8 to 10 as per ton of manure and the price of farmyard manure at most localities is above Rs 18 per ton. Compost manure prepared from town wastes contains in general above 1 per cent of nitrogen and 0.8 per cent of phosphoric acid while farmyard manure as ordinarily prepared by farmers contains only about half the above quantities of nitrogen and phosphoric acid.

(vii) In the improved system of compost making in trenches smell and fly nuisance are completely controlled and as such the night soil depot may be situated even at a distance of a few furlongs only from the town as against the present practice of having the depot situated about 2 to 3 miles from the town. As such transport charges incurred by the municipality for carrying night soil and *katchra* to the refuse depot may be cut down considerably. The night soil depot instead of being an unbearable spot to visit as at present would under the compost system become a clean and hygienic centre of manure preparation.

(viii) By adopting the compost system the municipality would help to return to the surrounding agricultural area the major part of the manure constituents which originally came into the town from the rural areas in the form of food and other agricultural products and thus the present one way drain from the rural areas to the towns would be converted into a cyclic one returning the products ultimately back to the rural areas. Under this arrangement the total productive capacity of our lands would not show appreciable deterioration over a stretch of time.

COMPOSTING PROCEDURE

(i) *Compost depot*—(a) The site selected for the compost depot should be at least 2 furlongs away from the outskirts of the town though it is possible to carry on composting without creating any nuisance even when the depot is nearer as at Nasik and Pandharpur provided the compost making is carried

out under proper supervision and in strict conformity with the instructions given. The site should preferably be not situated on the western side of the town since the wind generally blows from west to east most part of the year. It is not advisable to have the compost depot more than $\frac{1}{4}$ mile from the outskirts of the town since the transport of *katchra* and night soil to the depot becomes then more expensive and difficult. In the case of bigger cities it is advisable to have two or more compost depots situated on different sides of the town so that the distance to be covered by the *katchra* and night soil carts may be lessened. The production capacity of each depot should however be not less than 2000 tons per year in order to minimize supervision and labour charges.

(b) The composting is preferably carried out in trenches arranged in rows (such that the longer sides are parallel and the shorter ends are in the same line) leaving 5 to 6 feet vacant space between successive trenches. There should be suitable cart tracks on both the shorter ends of the trenches so that the *katchra* or night soil may be emptied at either end of the trench as desired. If new trenches are dug the mud excavated should be heaped along the longer sides leaving the shorter ends free for the *katchra* or night soil carts to approach the edge and deposit the refuse straight into the trench. The convenient size of the trench would vary with the population and quantity of refuse to be dealt with. Recommended dimensions are as follows—

Population	Size of the trench		
	Length	Breadth	Depth
Below 5 000	1 ft	5 ft	3 ft
5 000 to 10 000	20 ft	6 ft	3½ ft
10 000 to 20 000	5 ft	7 ft	4 ft
20 000 to 30 000	30 ft	8 ft	4 ft
30 000 to 50 000	35 ft	8 ft	4 ft
Above 50 000	40 ft	9 ft	4 ft

Trenches of bigger size than 40 ft × 9 ft × 4 ft are not recommended as being inconvenient to manipulate.

A suitable layout for the compost depot is shown in Fig 1. The installation shown contains 100 trenches of size 30 ft length 8 ft breadth and 4 ft depth distributed in rows such that there is road approach at both ends of the trenches. The whole area occupied is about 2 acres and the depot is capable of dealing with the refuse of a town of population 25 000 to 30 000.

(ii) *Type of soil in the depot*—For compost making it is not necessary that the trenches should be dug in black soil area. In fact any type of soil *murum* loam or even granitic would be suitable for digging trenches since the absorption and removal of moisture from the night soil is effected by the *katchra* while undergoing microbial decomposition. The disadvantage of a *murum* or granitic soil would be the difficulty of digging trenches to the required depth in such areas. In the case of loose soils the sides of the trenches are likely to get loose and fall down after some time. A similar difficulty may be felt in the case of black soils which crack badly in the summer. In the above cases it would be advisable to leave

a larger vacant space say 6 ft between successive trenches so that the individuality of the trenches may persist. If the trenches are kept filled up properly with compost the chances of the sides getting loose and falling down would be minimized. In any case it is unnecessary to brickline the trenches since this would involve prohibitive capital expenditure.

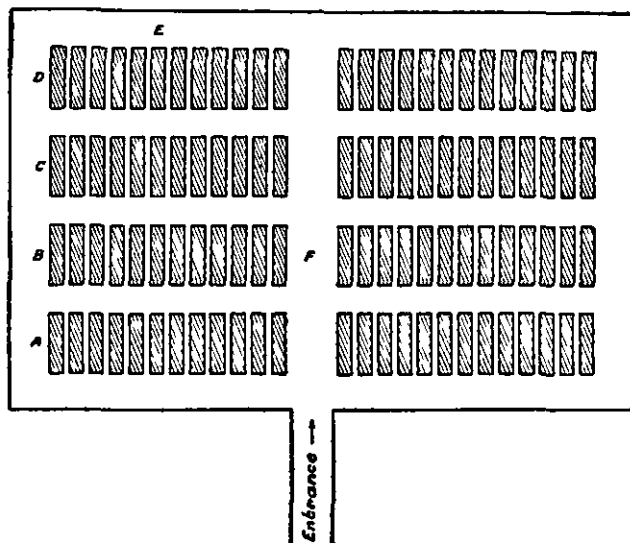


FIG 1 Plan of compost depot

(iii) *Compost data*—The following data may prove useful in compost calculations.—The output of municipal refuse is generally estimated at about $\frac{2}{3}$ to $\frac{3}{4}$ lb of *katchra* and $\frac{1}{4}$ to $\frac{1}{2}$ lb of night soil per head of population per day though there is much variation between different places on account of local factors such as industrial activity local habits of the people dilution of night soil with ablution water etc. For a unit of 10 000 population it is generally found that 800—1 000 tons of *katchra* and 500—600 tons of night soil (1 ton equals about 220 gallons) are collected on the average per year. The total compost manure that can be prepared by mixing the whole of the *katchra* and night soil together may be estimated at about 1 000 tons per year per 10 000 population—though the production capacity may show considerable variation from place to place—and tends to come down rapidly in centres of less than 10 000 population on account of local habits which permit the municipality to collect from 30 to 50 per cent only of the total quantity of *katchra* and night soil available from the total population.

The approximate weights of municipal refuse are as follows—1 cft of *katchra* 20 lb 1 cft of night soil 60 lb 1 gallon of night soil sewage sullage or blood 10 lb 1 cft of compost manure 40 lb. Good quality compost manure prepared from town refuse and night soil contains about 30 to 40 per cent moisture and on the dry basis above 1.0 per cent of nitrogen and 0.8 per cent of phosphoric acid whereas farmyard manure as usually prepared by farmers contains only about half the above quantities of nitrogen and phosphoric acid. Since the sizes and carrying capacity of carts vary enor-

mously from one part of the country to another ranging from 25 cft to 50 cft it would be preferable to express quantities of refuse or compost manure in terms of weight (as tons) or by volume (as cft). Roughly however it may be stated that a single bullock cart would take $\frac{1}{4}$ to $\frac{1}{2}$ ton of manure and a double bullock cart $\frac{1}{2}$ to $\frac{3}{4}$ ton of manure.

(iv) *Composting procedure*—The actual composting procedure is as follows.—First a layer of *katchra* about 9 to 10 inches thick is spread at the bottom of the trench and over this is added the calculated quantity of night soil corresponding to a thickness of 3 inches. From the data for the length and breadth of the trench and the data given in the preceding paragraph it is possible to calculate the number of cart loads of *katchra* and night soil to be added for each layer. Succeeding layers of *katchra* and night soil are similarly added till the heap rises to a foot above ground level. Each layer of night soil should be immediately covered over with *katchra* and the top layer at the end of each day should be *katchra* about 9 inches thick. If loose earth be available it is a good practice to cover the top of the heap at the end of each day (whether the trench is half full or completely full) with a thin layer of earth about $\frac{1}{2}$ to one inch thick since this effectively prevents any fly breeding and avoids smell nuisance altogether. In the case of the bigger towns it would be found convenient to take up two or three trenches simultaneously for filling in order to cope with the irregularity in arrival of *katchra* and night soil carts.

The proportion of *katchra* to night soil given above viz 9 in to 10 in layer of *katchra* and 3 in layer of night soil corresponds to equal weights of *katchra* and night soil but in towns where the total weight of *katchra* collected is greater than the weight of night soil collected the proportion of *katchra* used for each layer of compost may be increased up to a limit of two parts by weight of *katchra* to one part by weight of night soil. It would be a good plan to fix beforehand subject to the above limits the number of cart loads of *katchra* and night soil to be added to each layer such that the whole of the *katchra* and night soil collected daily is added to the trench without any excess of either being left over unless some portion of the refuse is urgently needed for other purposes e.g. for filling up hollows inside the town etc.

If the proper proportion of *katchra* to night soil be maintained in the trench a man's legs should not sink when walking over the compost mass at the end of each day. If the legs sink it shows that excess of night soil is present and hence more of *katchra* should be added. In a few days time after filling up a trench (3 or 4 days) considerable heat (over 60°C) should be produced in the mass which can be tested for by digging out a portion of the mass to a depth of 1 or 1½ ft. This intense heat which should persist over two to three weeks serves rapidly to decompose the night soil and *katchra* and to destroy all pathogenic organisms that may originally be present in the night soil or *katchra*. At the end of four months

decomposition the manure is ready for application to land and the resulting product is found to be a well decomposed odourless innocuous material of high manurial value superior to ordinary farmyard manure

After filling up half a dozen trenches it would be found that the first trench has sunk to a depth of a foot or more below ground level in which case further layers of night soil and *katchra* may be added on top of the above trench till its level rises to a foot above ground level. Further such additions to the same trench may not be necessary at later stages since the rate of sinking becomes much slower after the initial 15 days. In the rainy season however it would be advisable to raise the level of all the heaps to a foot or so above ground level (with *katchra*) and make the top of the heap dome shaped so that rain water may not collect in the trenches but may all flow out.

The labour required for the above process may be estimated from the fact that a labourer can deal with about 120 c ft of *katchra* (about a ton) and 200 gallons of night soil (about a ton) per day. The cost of production of manure works out to about 8 to 10 as per ton of compost manure obtained finally (50 to 60 c ft) charging labour at 8 as to 10 as per day.

Compost manure more than four months old can be sold away to cultivators and the trenches which thus become empty can be used over again for preparing fresh compost manure. Recommended dosages are from 20 to 25 cart loads of manure for irrigated crops and 5 to 10 cart loads for dry land crops.

(v) *Preliminary treatment*—It is generally unnecessary to give any preliminary treatment to or sorting out of *katchra* and the same can be directly added to the trench. While spreading the *katchra* in the trench however big size articles such as tin porcelain iron pieces brick bats glass etc may be taken out by hand and thrown on the bund of the trench to be removed later to the special dump heap of the depot. In some of the bigger cities it pays labour to collect and sell away marketable articles such as tin waste iron glass waste paper card board bone pieces etc and sometimes a decent margin of profit could be secured from this source. From the point of view of the agriculturist who does not require the above things to be put on the land the same could be removed in a simple manner at the time of purchase of the manure by keeping a $\frac{1}{2}$ inch expanded metal sieve on top of the cart and throwing the baskets of manure over the sieve. The undesirable materials collect on the sieve and can be shaken off from time to time.

(vi) *Covering trenches with earth*—In cases where the compost depot is situated quite adjacent to the town and where there is plenty of loose earth available near the trenches it would be a good practice to cover the compost heaps in the trenches with a thin layer of earth say about $\frac{1}{2}$ to one inch thick. This completely stops any smell coming out of the trench even on the first day of filling up the trench and also prevents fly breeding. In addition the layer of earth helps to conserve moisture better in the compost mass. The main drawbacks of the

earth cover are—(a) increased labour charges due to placing an earth cover (b) possible difficulties in obtaining supplies of loose earth at the depot and (c) delay in decomposition and heat production due to decreased supply of air.

In cases where the compost depot is newly established and trenches are dug fresh there is plenty of loose earth available at the depot and there is sometimes a tendency to put too thick a layer of earth on top of the trenches. This considerably minimizes the aerobic conditions needed in the early stages and consequently hinders rise of temperature and retards proper decomposition. The layer of earth put on the top of the trench should preferably not exceed half an inch in thickness.

Where the compost depot is an old one and already existing trenches are being re used for compost making very little loose earth may be available for covering the top of the heap. In such cases it would be advisable to use the previous season's old manure for covering the top of the heap to a thickness of about 3 to 6 inches which would give most of the advantages of an earth cover by way of better retention of nitrogen and of moisture. The following procedure may be found useful for routine adoption in such cases. When the old trenches are ready for sale it would generally be found that the top 6 in to 8 in layer of refuse is not properly decomposed and the farmers are unwilling to cart the same as manure. It would be a good plan to keep the top 6 to 8 in layer heaped on the vacant 5 to 6 ft bund between adjacent trenches and sell the well decomposed manure below the above layer. When the trenches have been emptied and are later re filled with *katchra* and night soil the top of the trench could conveniently be covered by the above old refuse kept on the adjoining bund.

(vii) *Accessories and tools*—In cases where the night soil is transported in cylinders having an outlet at the bottom it would be found convenient to connect the outlet (by means of coupling) with the wide bore L shaped iron spout (Fig 2) in order to facilitate the easy discharge of the night soil into the trench. The system is found to work satisfactorily in cases where the night soil is rather dilute. In cases where the night soil is thick it is found more convenient to fix to the outlet at the bottom a straight funnel like spout and then to keep a *gurni* (scoop like tray) of thick galvanized iron sheet of the shape shown in Fig 3 at the edge of the trench so as to catch the night soil as it flows out of the cylinder and lead it into the trench. In smaller centres the night soil is usually transported in the box like iron containers (Fig 4) provided with opening at the top and emptied by being tipped over so as to invert the container completely upside down. In such cases no special attachment of spout or *gurni* is necessary as the force with which the contents of the drum come out is generally enough to carry the night soil straight into the trench.

For the spreading of *katchra* in the trenches it saves labour considerably if—(a) the supply of *katchra* is dumped at both ends of the trench so that the *katchra* has to be dragged over only half the

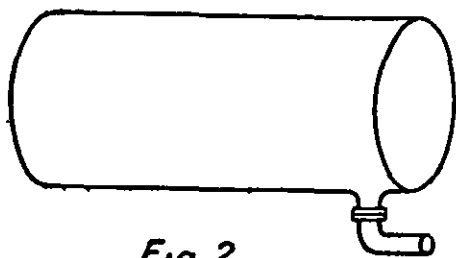


Fig 2

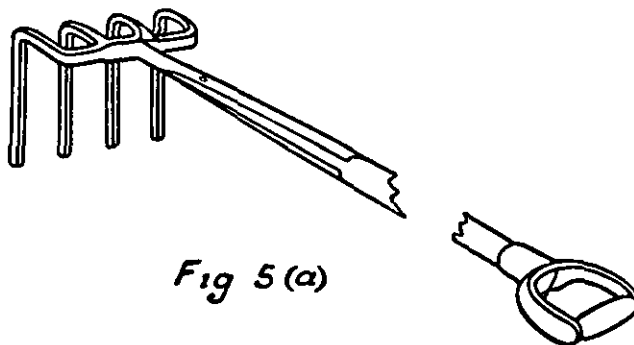


Fig 5(a)

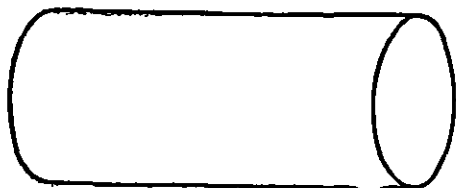


Fig 3

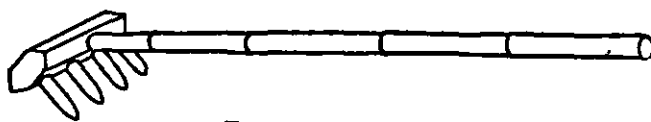


Fig 5(b)

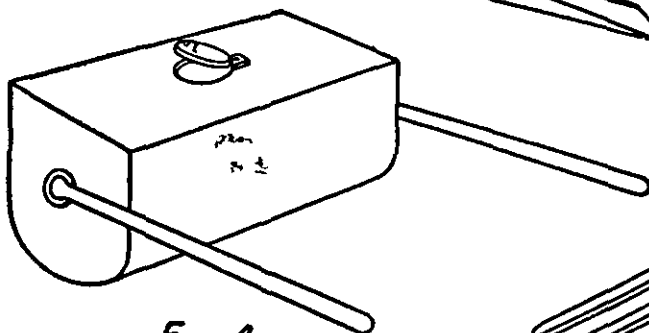


Fig 4

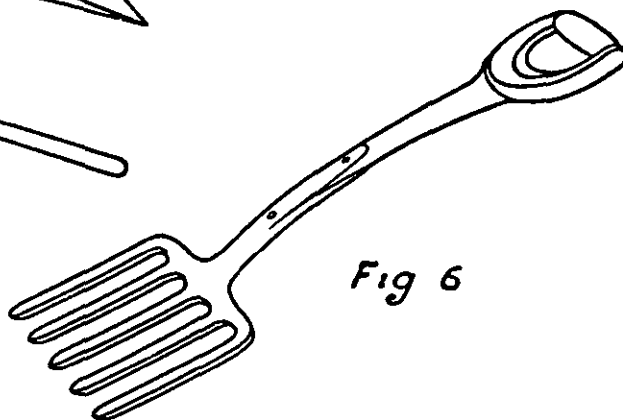


Fig 6

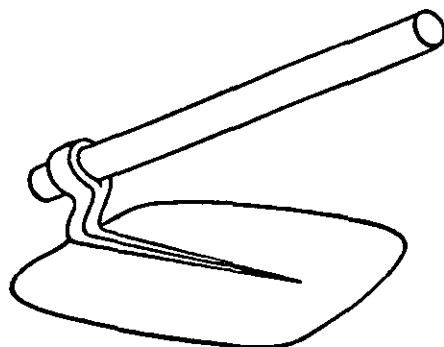


Fig 7

length of the trench and (b) long handled rakes [Figs 5(a) and 5(b)] are used for dragging the *katchra* into the trench instead of *phowdas* (Fig 7) The

rakes may be made locally and should be light the handle being of wood or bamboo 5 to 6 ft long and the prongs being of iron The prongs should be

fixed to a strong wooden cross piece which is fixed to the handle in such a way that when the rake is working the handle makes a gentle slope with the horizontal. If *katchra* be available at both ends of the trench one man can easily spread 100—120 c ft of *katchra* in four to five hours by means of the rake. While levelling the *katchra* in the trench a gentle slope should be given from one end to the other so as to facilitate the easy flow of night soil.

While digging into a compost trench for examination or removal of manure therefrom a fork is found very useful (Fig 6). In a fork the handle is shorter as compared to a rake and it is almost in the same plane as the prongs. It is very convenient for digging purposes. For collection of odd amounts of *katchra* or night soil lying about here and there a *phowda* (shovel) is useful (Fig 7). Before collecting small quantities of night soil that might have been spilt on the sides of the trench the same should be covered over with loose earth and the mixture should be scraped out. Long handle brooms could effectively be used for keeping the compost area clean. Other useful accessories for compost work would include a measuring tape and a spring balance weighing up to 200 lb.

All compost trenches should be serially numbered and a daily record of the quantities of refuse arriving at the depot and the quantities added to different trenches should be maintained at every depot. From the above daily record a trench ledger showing the history of each trench should be prepared.

(viii) *Moisture conditions in the heap*—Normally when the proportion by weight of *katchra* to night soil is 1:1 the moisture content of the compost mass is about 45—50 per cent at the start and especially when the depth of the trench is 4 ft the moisture is conserved satisfactorily enough to promote vigorous microbial action and rapid decomposition of the mass. It may so happen however that after about a month the top layer of the refuse to a thickness of 1 to 1½ ft may get dry in the summer season especially if the temperatures are high. Under such conditions one of the following alternative treatments may be adopted in order to provide enough moisture for the decomposition of the top layer—(a) if the level of the compost mass in the trench has sunk a foot or more below road level a further layer of night soil may be added on top of the heap and this may be covered over with a fresh layer of *katchra*. (b) if the level of the compost mass in the trench is almost near ground level the top dry layer of refuse may be drawn back to the four sides of the trench so as to form a basin like depression of a foot depth in the trench. Into this basin is added a cart or lorry load of night soil after which the *katchra* heaped at the sides is again drawn back so as to cover the night soil. (c) where the compost mass in the trench is more than three months old and the sale season of the manure is approaching in a month or two and it is considered inadvisable to add a fresh layer of night soil on top a cart or lorry load of sullage water may be added on top of the trench if it be dry. After the addition of sullage water some basketfulls of *katchra*

may be sprinkled on top in order to keep down smell and fly breeding. As an alternative the top dry layer of refuse in the trench may be scooped out basin form as in (b) above and a cart or lorry load of sullage water may be put in and the original *katchra* drawn back from the sides as a cover.

Tests should be made occasionally for sufficiency of moisture in trenches by digging out in some sample trenches and seeing at what depth there is moisture in the mass. If moisture is found only lower than one foot from the top and the moist layer below is not slushy it would indicate the need for addition of water.

While adding sullage or sewage water to a trench great difficulty is felt in making it spread along and moisten the whole length of the trench unless a hose pipe is used. A simpler method would be to make the surface of the refuse slope down by a foot from each end to the centre of the trench and add a cart load of sullage water at each end when it would be possible to wet the whole length of the surface. It would be better to add the required quantity of water in two or three weekly doses so as to prevent the rapid passage of water down to the lower layers and accumulation there leading to a slushy mass undergoing putrefactive decomposition at the bottom of the trench.

The addition of extra water should be stopped a month before the rainy season. During the rainy season efforts should be made to prevent entry of rain water into trenches by adopting the following precautions which become important in areas where the rainfall exceeds 50 in: (a) The compost heaps in all trenches should be brought to a level 1½ to 2 ft above ground level by addition of fresh layer of night soil followed by *katchra*. The top of the heap should be made dome shaped so that the rain water falling on the heaps may run out. Where loose earth is available it would facilitate the running out of rain water if the top of the heap after raising it above ground level is covered over with a layer of earth say an inch thick. (b) In order to prevent rain water flowing into the trenches from the surrounding area the sides of the trenches may be raised with earth and made to slope down on all sides and suitable drains may be provided for carrying off the storm water. These arrangements are easier to make in a depot where the trenches have been newly dug up and plenty of loose earth is available. The provision of bunds all round the trenches would be specially necessary in cases where the depot is in a low lying area and plenty of water runs into the depot area from the surrounding high level lands.

(ix) *Proportion of katchra to night soil*—The relative weights of *katchra* and night soil collected vary greatly from centre to centre. Where the relative proportions are equal (by weight) the composting is simpler since the moisture supplied by night soil is generally sufficient to carry the composting to a successful stage. Special difficulties may however arise in centres where the proportion of *katchra* collected is either much greater or much less than that of night soil. A higher proportion of *katchra* is generally obtained in the bigger cities where

the output of dry refuse per head of population is high. In other centres the output of night soil collected may be artificially increased due to local habits whereby ablution water and urine get admixed with night soil proper.

In cases where the weight of *katchra* is greater than that of night soil the deficiency of moisture may be made up by adding a cart of sullage water after each cart of night soil such that the total weight of sullage water plus night soil equals the weight of *katchra* put into the trench. In cases however where the night soil is dilute and is in excess of the weight of *katchra* the best course would be to add the excess of night soil as fresh doses on top of one or two months old composts where the mass has sunk below ground level. After this addition the top should be covered with a layer of fresh *katchra*. The system will be found to work satisfactorily after 40 or 50 trenches have been filled up with compost and there is increasing scope for adding fresh doses of night soil on top of old trenches.

(x) *Areas of high water table*—In areas of high water table it may be possible to locate the depot at a special spot having comparatively higher elevation where trenches could be dug to a depth of 3 to 4 ft without reaching the water level. Where such an arrangement is not possible it would be necessary to carry out the composting in heaps overground in the following manner—A circular layer of *katchra* two feet high and of suitable dimensions say 10 ft diameter is first spread on the ground. More *katchra* is added on the rim all round so as to raise the edges 2 feet higher and form a circular basin inside. Into this circular basin is added the calculated quantity of night soil such that the weight of night soil taken is half the quantity of *katchra* used. After the addition of night soil the *katchra* at the rim is drawn up so as to form a closed hemispherical heap. The top of the heap is completely covered with a layer of dry earth about $\frac{1}{2}$ to 1 inch thick and the heap is left undisturbed for a month. After a month the heap is given a complete turning to the adjacent position made again basin form and a second addition of night soil is made equal in weight to the quantity originally used. The sides are again drawn up to close the heap which is then covered over with earth as before. After two months maturation the manure is ready for sale to farmers.

The above overground method dispenses with the use of trenches but involves much greater amount of labour charges than the trench system. Hence the manure obtained by the method is proportionately costlier.

(xi) *Slaughter house wastes*—The method of composting slaughter house wastes is similar to that of composting night soil. Over a layer of *katchra* 8 to 9 in thick is placed a layer of slaughter house wastes (waste meat liver intestines offal hoof dung etc.) about 4 to 5 in thick. This is covered with a layer of *katchra* about 8 in thick. In order to provide the necessary moisture a layer of night soil is next added 3 to 4 in thick and covered with *katchra*. Where night-soil is not available a cart-

load of sullage water may be added at the rate of 100 gallons for every 100 c ft of *katchra* put into the trench. Instead of sullage water blood washings from the slaughter house can conveniently be used at the above rate. After the addition of blood washings or sullage water a layer of slaughter house wastes is again spread followed by *katchra* and the operations are repeated till the trench is filled up. It is found that slaughter house wastes decompose rapidly and a manure of good quality is obtained in three to four months time. Pieces of bones hoofs horn and other resistant organic matter may also be added into the trench and would be found to have softened considerably during composting due to microbial action.

(xii) *Composting of katchra*—Septic and activated sludge filter bed residues and raw sewage may with advantage be used as nitrogenous starters for composting *katchra* (dry refuse) in place of night soil or slaughter house wastes. The main drawback of the above materials is their high dilution with water and the low percentage of nitrogen contained in the diluted condition. Septic sludge may contain 40–70 per cent moisture and on the dry basis 1.5 to 2.0 per cent nitrogen. Activated sludge may contain up to 98 per cent moisture and on the dry basis 5 to 6 per cent nitrogen. Raw sewage contains normally from 5 to 10 parts of nitrogen per 100 000 parts which amounts to less than 0.01 per cent of nitrogen. On account of the low percentages of nitrogen contained it is difficult to supply the nitrogen requirements of *katchra* by way of sewage or sludge unless the latter has been partially dried. Hence the decomposition is often slow when the above starters are used.

Where sewage or dilute sludge has to be used for composting *katchra* it is preferable to carry out the composting in overground heaps [section (x)] giving two fortnightly turnings to the mass in order to promote aeration and adding fresh doses of sludge or sewage at each turning to make up for moisture requirements and finally plastering the mass with earth. After another two to three months maturation the manure would be ready for application to land. Where partially dried sludge (e.g. 20 per cent moisture) is available (septic or activated) composts of good quality can be obtained by placing alternate layers of *katchra* and partially dried sludge in trenches (in the proportion of one part of septic sludge or $\frac{1}{2}$ part of activated sludge for every part by weight of *katchra*) and moistening the mass with sewage or sullage water at the rate of 150 to 200 gallons for every 100 c ft of *katchra* put into the trench. The other details of composting would be the same as those given already for the treatment of night soil or slaughter house wastes.

(xiii) *Periodical tests*—Though the Mukadam or Maistry in charge of the compost depot may be efficient enough to carry out instructions properly without frequent check periodical tests and observations should be made by the health officer or sanitary inspector in-charge in order to examine whether any modifications of the instructions given are necessary in order to suit local conditions.

Among the tests and observations to be so made are the following —

(a) Sanitary factors such as cleanliness absence of smell fly breeding etc

(b) Development of high temperatures in the trenches during the first week after filling up a trench which can be tested for —(i) by digging with a fork a foot deep from the surface and noting the warmth of the mass evolution of steam etc the extent of fungal development (white mycelia) should also be noted —(ii) by thrusting an iron rod into the compost mass to a depth of 2 feet from the top keeping it there for some minutes then withdrawing it and noting its warmth by hand or (iii) by inserting a long stem thermometer in the compost mass and noting the temperature at different depths of the heap Absence of high temperatures (60 C and higher in the first week) would indicate either in sufficient or excessive moisture or lack of proper proportion between *katchra* and night soil

(c) Presence of sufficient moisture in the compost mass This can be tested for either by digging out a portion of the mass and noting at what depth moisture makes its appearance or by inserting an iron rod to a depth of 2 to 3 ft and after withdrawing it noting the length of the rod which has been moistened with water Deficiency of moisture should be made up by methods already indicated

(d) The extent to which different trenches have sunk Based on the age of the trench and proximity of the sales season instructions should be given for adding fresh lots of night soil and *katchra* on top of old trenches Before the monsoon period all trenches should be raised above ground level and precautions should be taken for preventing rain water from getting into the trenches

(e) Periodical observations should be made on the rate of decomposition and ripeness of manure formed in trenches as judged by colour stage of breakdown or appearance of the manure so that indications may be obtained regarding the minimum period of storage necessary in trenches under local conditions and estimates may be prepared of the total quantity of manure that would become ready for sale in any particular season The daily record and trench ledger maintained at the depot would be found useful in arriving at the above estimates

(XIV) *Marketing compost manure*—Municipalities maintain sanitary staff who can supervise the work of preparation of compost manure on proper lines but they have very few facilities for getting into touch with agriculturists who may need the manure Often the municipality entrusts the sale of the manure to a contractor at amounts fixed at annual auctions This system means lesser income to the municipality and enhanced prices so far as the agriculturist is concerned resulting in decreased over all demand for the manure Several municipalities have success fully undertaken the direct sale of the manure to agriculturists at rates fixed low enough to be attractive to the farmers and at the same time to cover all expenses of preparation of the manure

Since the agricultural and rural development departments are primarily interested in the supply of manure to agriculturists municipalities should enlist the active cooperation and help of the local officers belonging to the above departments for disposing of the manure prepared by them These officers are in touch with the agriculturists and have facilities for carrying on active propaganda which could create and establish a ready market for the sale of the manure prepared by the municipality

TABLE III — *Approximate chemical composition of town wastes and compost manure prepared therefrom*

Material	Percentages on fresh material			Percentages on oven dry material				
	Moisture	Dry matter	Organic matter	Carbon	Nitrogen	Phosphoric acid (P O)	Potash (K O)	Calcium (CaO)
1 Town refuse (sw epl gs and dust bin refuse)	10—15	85—90	25—30	14—15	0 7—0 8	0 4—0 5	1 2—1 4	7 0—8 0
2 Night-soil	75—80	20—25	19—24	45—50	5 5—6 0	4 0—4 5	2 0—2 5	4 5—5 0
3 Urine	93—95	5—7	4—5	12—15	18—20	2 8—3 0	3 4—3 6	5 0—5 5
4 Sewage	99 85— 99 95	0 05—0 15	0 038—0 08	25—30	6—10	3 0—4 0	3 5—4 0	5 0—6 0
5 Animal blood	77—80	20—23	19—22	35—40	13—15	1 0—1 5	0 8—1 0	2 0—2 5
6 Mixed slaughter-house wastes (solid)	75—80	20—25	18—23	15—16	8—10	3 0—3 5	2 0—2 5	3 0—3 5
7 Compost manure prepared from <i>katchra</i> and night-soil	35—45	55—65	16—20	14—18	1 2—1 5	1 0—1 2	1 4—1 6	8 0—9 0
8 Compost manure prepared from <i>katchra</i> and slaughter house wastes	40—50	50—60	16—20	15—20	1 4—1 8	1 2—1 5	1 2—1 4	9 0—10 0