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Bio-Gas Plants Based on Night Soil and/or Animal Dung

Excerpt from a paper presented by Dr. B.R. Nagar, Indian Agricultural Research Institute, New Delhi, India, at FAO/SIDA Expert Consultation on Organic Materials as Fertilizers, Rome, Italy, December 1974.

Popularisation of bio-gas plants

The desirability and need to conserve cow dung as manure has assumed great importance, and this all the more so since chemical fertilizers are in short supply. A highly desirable objective is to use another cheap fuel in place of cow dung, thus making it available as manure.

Need for bio-gas plants

Cow dung, when processed through a gas plant, yields a good quality manure and gas for cooking and lighting. The gas plant is thus a veritable boon for the farmer for various reasons:

- The manure obtained from cow dung gas plants is richer as it contains about 1.5 % nitrogen against 0.753 % in farm yard manure.
- The heat efficiency of the cow dung burnt in the traditional manner is not more than 11 % while cow dung gas burnt in properly designed burners has a heat efficiency of 60 %.
- Dung gas manure is richer in humus, which is important for improving the physical characteristics of soil, namely water retention capacity, prevention of water logging, good aeration, etc.
- Dung gas manure due to its fine particle quality mixes well with soil.
- It helps improve the villages' sanitary condition by preventing fly breeding, etc.
- The manure is free from offensive odour normally associated with manure pits.

Working principle:

The gas plant operates on the simple principle that when dung or any other organic material is fermented in the absence of air, the combustible gas, methane, is produced.* In bio-gas plants this fermentation is carried out in a brick-lined tank which is filled with dung made into a liquid slurry with water. This is then covered with an iron drum introduced upside down in the tank which serves to cut off air and provide the necessary conditions for fermentation. The gas produces bubbles inside the drum which gradually fills up and begins to float and rise. The gas is taken through a wheel cock fixed to the top of the drum and led to the kitchen by pipes and burned through suitable burners. Maintenance of gas production is achieved by feeding about 50 kg fresh dung daily through a funnel pipe which carries the slurry to the bottom of the tank. The spent slurry overflows from the top of the tank and collects in a pit from where it is periodically removed and added to the compost pit.

* Note from the editor: Since night soil and cow dung decompose anaerobically, the temperatures needed for the destruction of pathogenic organisms are not reached. The hygienic aspects should therefore be carefully examined.

Prerequisites:

The individual or the institution must have a sufficient amount of dung or night soil. The animals should preferably be stable bound. There should be at least 45 kg of fresh dung every day. This will enable the setting up of a two cubic metre (60 c.ft.) gas plant. On an average, the daily droppings expected from a medium-size cow, buffalo or bullock, amount to about 10 kg (fresh weight). Gas plants can also be fed entirely on night soil. At least 60 adults are needed to warrant the construction of the smallest size gas plant. This is normally possible only in the case of hostels, public latrines etc. Roughly about 5 livestock units or 60 persons are essential for establishing a 2 cubic metre gas plant.

- Sufficient space must be available for constructing the gas plant and for location of pits for outlet slurry. This space again must be in the immediate vicinity of the stable and close to the place where gas is to be used. Normally the distance should be within 20 metres.
- A sufficient quantity of water must be available. Normally the cattle dung is mixed with an equal quantity of water before being fed into the gas plants.
- Besides cattle dung and night soil, it is also possible to establish a gas plant where waste from flaying centres is available in sufficient quantity. Hog and poultry excrements if available in sufficient quantity, can also be employed for this purpose.

Installation of the gas plant:

The gas plant should be located near the kitchen, in open space and away from any wall or tree so as to be in the sun as much as possible. This will ensure better fermentation and better gas production.

Construction:

A family size gas plant yielding about 3 cubic metres of gas requires a daily supply of 50 kg of fresh dung which is sufficient for the cooking requirements of a family of about 6 to 8 members.

To start, a fermentation tank (F), 2 metres in diameter is dug to a depth of 4 metres. A sloping channel (E), of 15 cm diameter is dug to a horizontal distance of 60 cm from the tank and carried to a depth of 65 cm above the bottom of the tank. The bottom is then brick-floored and plastered with cement. A tank one-brick thick is now raised from the bottom, keeping an internal diameter of 1.65 metres of the tank. The feed pipe (E) is then fixed in position in the channel and buried with one end projecting 10 cm inside the tank and the other about 35 cm above the ground level. Brick lining of the tank is then continued to a depth of 1 metre from the top. At this point 3 brick cornices (R) projecting 15 cm into the tank are constructed to support the gas holder. Alternatively 3 stone slabs or angle iron pieces, each 40 cm long, can be fixed projecting 15 cm into the tank. The brick tank is then continued and finally raised 30 cm above ground level. A channel (L), 10 cm wide is taken from the top for carrying the overflowing digested slurry to the compost pit (M).

Where the feed pipe (E) emerges out of the ground, a square brick structure 60 x 60 x 60 cms (G) is constructed about the pipe. This is filled with earth and then floored with bricks and plastered with cement, flush with the open end of the pipe. This construction serves as a funnel for daily feeding of dung slurry flowing down the pipe to the bottom of the tank.

(N) is a small brick lined pit, 30 cm square and 30 cm deep, just outside the tank which serves as a water catch to remove the condensed moisture from the gas pipe. By opening the tap periodically, once a week, the condensed water is let out and the pipe line for gas kept clear. The gas outlet pipe (J) with the wheel cock (S) is then connected as shown in the diagram and the pipe line taken to the kitchen where a suitable gas tap is fixed to take off gas for burning. The drum (B) is then carefully introduced into the tank so as to rest on the three projecting supports (R). Three 240 cm long angle iron posts or black iron pipes (A) 4.2 cm in diameter, with pulleys (D) on the top are then fixed at equidistant points outside the tank, emerging 180 cm above ground level. Three iron counterweights (C) are tied to lengths of twisted wire rope or iron chain (H), with the other end tied to each of the handles of the gas drum. The wires are then passed over the pulleys so that the weights keep hanging 45 cm from the ground level. The pipe line (J) is fixed to one of the supporting irons, with a bend at the upper end to which is attached one end of a 240 cm long hose pipe and the other end connected to the nipple in the drum.

Operation:

The gas plant is now installed and ready for operation. Dung is first made into a slurry with an equal proportion of water and discharged into the fermentation tank through the funnel until it is completely full. This may take a week or more and require about 1000 kg fresh dung to fill. The wheel cock of the gas holder should be kept open during the filling period to allow the air to escape. When the fermentation tank is full, the wheel cock is closed and the gas pipe line and the bend on the gas holder are connected by means of the rubber hose.

Production of gas normally starts within a week, the gas accumulates inside the holder, causing it to float and rise. The first gas after installation may not burn due to a high content of carbon dioxide. If so, detach the rubber hose and open the wheel cock to release the gas. The drum will settle down and again rise with fresh gas which may be similarly tested. When the gas is required, open the wheel cock on the drum and burn the gas through a suitable burner.

After the gas has first formed, production is maintained by daily feeding of about 50 kg fresh dung made into a slurry with an equal proportion of water. This produces about 3 cubic metres of gas daily, sufficient for cooking requirements of an average size family.

Larger size gas plants can be constructed on the same principle by increasing the dimensions of the fermentation tank up to 2.55 metres diameter and 4.5 metres depth with a gas holder of 2.4 metres diameter and 1.2 metres height to yield about 9 m^3 of gas daily.

Maintenance:

The gas plant can be maintained in working condition by attending to the following points:

- The gas collecting in the drum contains water vapour which gradually condenses in the rubber hose and the pipe line leading the gas to the kitchen. The pipe lines should, therefore, be laid in a small slope from the pit so that all the condensed water may collect here. For proper maintenance remove this water periodically by disconnecting the hose pipe and opening the water tap in the pit.
- In summer the slurry on top of the fermentation tank is apt to become so thick that the drum does not easily sink when released for use.
  The flame obtained is good to begin with but later becomes low. To remedy this, pour a few buckets of water directly into the fermentation tank and stir with a bamboo pole until the slurry becomes sufficiently thin. Shake the drum a few times and test the flame.
- The gas drum should be taken out and given a protective coating of paint at least once a year.

Disposal and use of the digested slurry:

The digested slurry overflowing daily from the top of the tank when fresh dung is fed is led by means of a channel directly in a compost pit filled with leaves, straw etc, where it promotes decomposition of these materials and yields a large quantity of manure.
If there is no space available for a compost pit near the gas plant, the liquid slurry may be collected in a smaller pit from where it may be cleared periodically and either spread onto land directly or put in a compost pit. Leaf powder, paddy husk, saw dust and other such waste materials can dehydrate liquid slurry. It may be dried further in the sun and stored for use when required.

Stimulating gas production in winter:

In the north, the yield of gas obtained in winter is reduced to about one-third, due to the effect of low temperature on the activities of the microorganisms. This difficulty can be overcome by the following measures to stimulate bacterial activity:

- The addition of about 10 litres of cattle urine to 50 kg dung daily will considerably increase the yield of gas by stimulating fermentation. Arrangements can be made for collecting the urine fraction in cattle sheds as such or by absorbing it in suitable litters which can then be immersed in water and the extract put in the tank.
- The water for preparing dung slurry may be kept exposed to the sun for the day and used in the evening for mixing with dung.
- About 1 kg of powdered leaves or wheat straw mixed with 50 kg dung will give an increased yield of gas and provide simpler energy material for the fermenting microorganisms.
- Cover the gas plant with wood or polyethylene to maintain higher temperatures inside.

Use of bio-gas:

Cooking

The gas is excellent for cooking purposes since the blue and smokeless flame provides neat and efficient fuel. Suitable ring gas burners of different sizes are available on the market for this purpose. The Indian Agricultural Research Institute has also designed the following cheap and simple burners which can be easily constructed.
(a) **Tin burner:** This can be made from an empty cigarette tin by drilling a 0.7 cm hole in the side, about 2 cm from the bottom, and soldering a 7 cm long tube of this diameter with 3 cm inside and 4 cm from outside. The lid is perforated with a 2 mm nail in a circle of 4 holes with one hole in the centre. The tin is filled with a few stones for distribution of the gas. Gas passing inside the tin through the tube burns from the perforations at the top and yields a good flame for cooking. The burner is introduced in an earthen vessel on which is placed the cooking pot. (b) **Angithi burner:** This can be made from flat tins of the size of the usual boot polish tin or larger flat tins. A 0.7 cm metal tube bent at sight angles is soldered in a hole made in the bottom of the tin. The cover of the tin is perforated with 2 mm holes along the circumference with 2.5 cm space between the holes. This is fitted up in the usual iron angithi.

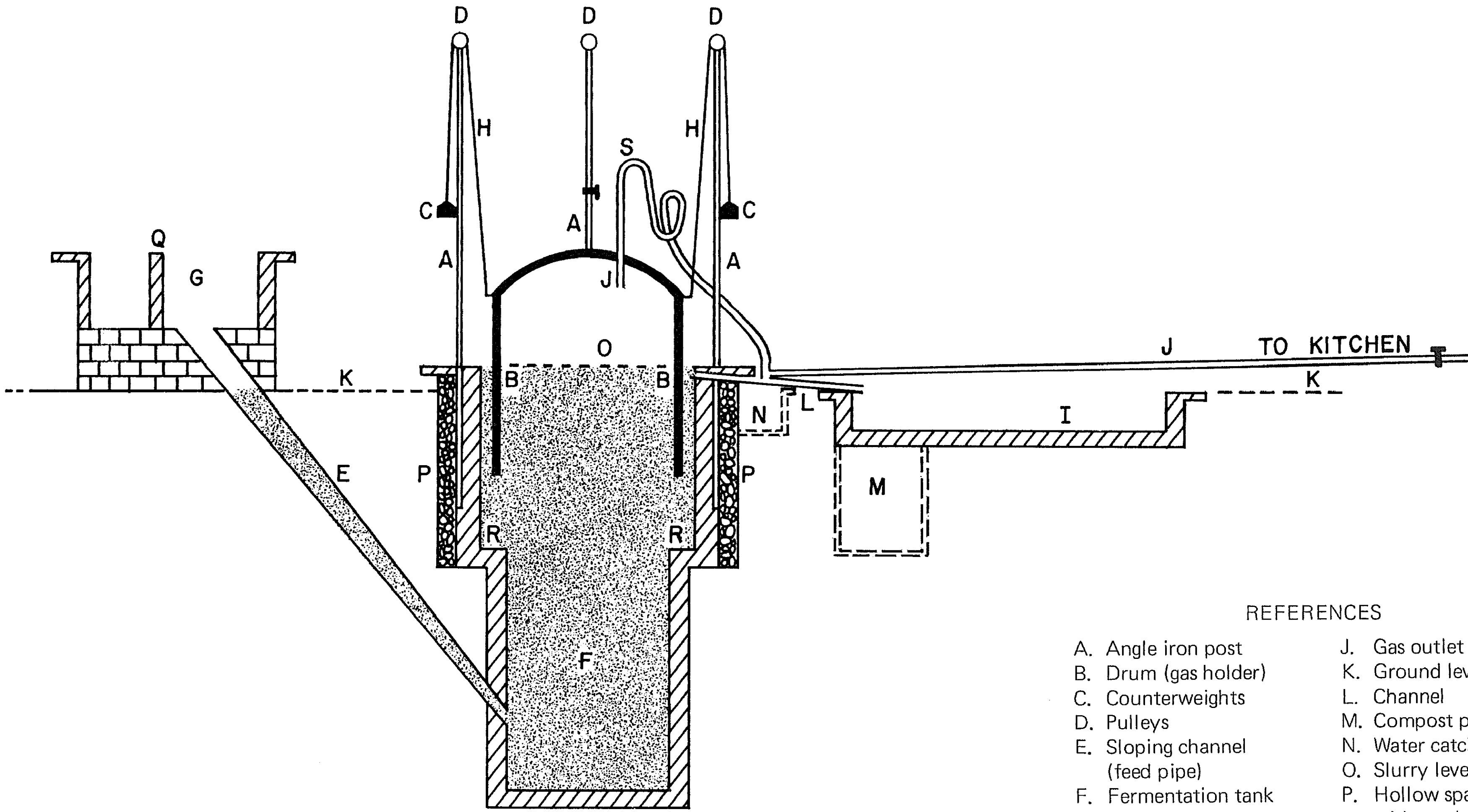
Lighting

Bio-gas can be used for lighting purposes for which suitable gas mantle lamps are available on the market. Their consumption of gas is about 0.12 m^3 per hour per mantle.

Power

The usual petrol, kerosene and diesel oil engines of any horse power can be adapted to run on bio-gas and the power generated utilized for pumping irrigation water, grinding flour, generating electricity etc. Adapted diesel oil engines are available on the market. Their consumption of gas is about 0.45 m^3 per horse power per hour. For this purpose large capacity gas plants can be constructed according to requirements. About 7000 gas plants have already been set up in India.

BIO-GAS PLANT



REFERENCES

A. Angle iron post	J. Gas outlet pipe
B. Drum (gas holder)	K. Ground level
C. Counterweights	L. Channel
D. Pulleys	M. Compost pit
E. Sloping channel (feed pipe)	N. Water catch with tap
F. Fermentation tank	O. Slurry level
G. Brick structure (for dung mixing)	P. Hollow space filled with sand or saw dust
H. Iron wire rope	Q. Wooden partition
I. Drying bed	R. Brick cornices
	S. Wheel cock

News from WHO

New WHO publications*

Slow Sand Filtration, by L. Huisman and W.E. Wood, Geneva, World Health Organization, 1974. 122 pages. Price: Sw. fr. 16.–. French and Spanish editions in preparation.
Slow sand filtration has proved to be a simple, reliable, inexpensive and efficient method of water treatment under widely differing circumstances. The book describes the design, construction and operation of modern slow sand filters, the theories of biological filtration, and the various methods of cleaning filters, which range from simple manual techniques to advanced mechanical or hydraulic systems. It shows how slow filtration can be matched to any level of technological development. It is hoped that the new publication will encourage the greater use of this method of water treatment, especially in developing countries.

Guide to Simple Sanitary Measures for the Control of Enteric Diseases, by S. Rajagopalan & M.A. Shiffman. Geneva, World Health Organization, 1974. 103 pages. Price: Sw. fr. 32.–. French edition in preparation.
A high incidence of enteric diseases associated with poor sanitation is characteristic of the disease picture in many of the developing countries of the world. The best ways of combating these diseases, from the cost-benefit and cost-effectiveness point of view, are the provision of safe drinking-water, the practice of food hygiene, and the sanitary disposal of excreta. The guide provides a compendium of knowledge on simple sanitary measures that can be implemented with limited resources to control enteric diseases; it is intended for the use of professional personnel responsible for public health and sanitary services in developing countries.

Community Water Supply and Excreta Disposal Situation in the Developing Countries: A Commentary, by C.S. Pineo and D.V. Subrahmanyam, Geneva, World Health Organization, 1975 (WHO Offset Publication No. 15). 41 pages. Price: Sw. fr. 12.–. French edition in preparation.
In 1971 and 1972 a global survey was carried out of community water supply and excreta disposal conditions and needs in the developing countries in both urban and rural centres. The statistical results country by country, depicting the situation as at the end of the year 1970, were published in the **World Health Statistics Report,** 1973, Vol. 26, No. 11. The present publication is an analysis and commentary on some of the salient data presented in the report and considers, **inter alia,** prospects for reaching the Second United Nations Development Decade targets. It is hoped that this paper will be of some value to those concerned with planning and assistance for community water supply and excreta disposal programmes in the developing countries.

* Available through WHO sales agents

New Concept for Sanitary Landfilling Porous or Impermeable Subsoil?

Translated excerpt from the article "Mülldeponie und Schutz des Grund- und Oberflächenwassers" (Sanitary Landfills and Measures for Surface and Groundwater Pollution Control) by Dr. Eberhard Hantge published in the technical periodical "Müll und Abfall" No 1, 1975.

When analysing percolating water of a sanitary landfill, enormous differences have been observed as to its pollution load. According to the author, only 1 % of the extractable polluting substance is leached out if free drainage on porous subsoil is warranted. This is due to the fact that rain-water flows through a few canals in the mass of refuse leaving the rest of the refuse completely dry.

Impermeable subsoil, however, generally impounds percolating waters thus saturating 20–30 % of the refuse mass. An additional quantity of percolating water makes the trough overflow and gives rise to highly polluted seepage.

It is generally taken for granted that sanitary landfills are set up on impermeable subsoils. Clay pits are considered to be especially suited for refuse tipping. Owing to the described trough-effect, unexpected difficulties, however, arise only after a few years of experience, particularly in the form of highly concentrated percolating waters requiring costly treatment. Test results of surface or groundwater pollution loads are briefly summarized for waste dumped on porous as well as on impermeable subsoil. For this purpose a landfill with a surface area of 10 ha, covered 10 m high with refuse is assumed and operated for several years. The following percolating water quantity was measured: 0.8 l/sec percolating water corresponding to 70 m^3/day.

1. Refuse deposited on porous subsoil

The organic pollution load measured as BOD_5: 11 kg BOD_5/day or approx. 270 PE_{40}. Dissolved substances, mainly inorganic salts, measured as residue on evaporation: approx. 406 kg/day.

2. Refuse deposited on impermeable subsoil

2.1 When dumped on impermeable pits with no risk of impoundage, the values obtained could correspond to the ones in 1.

2.2 For impounded percolating waters in the mass of refuse the following peak values were measured:
Organic pollution load: max. 1383 kg BOD/day or approx. 35 000 PE_{40}
Dissolved substances: 1050 kg/day

These figures reveal that considerable quantities of refuse components can be leached out from sanitary landfills set up on an impermeable fill if the refuse volume penetrated by rain-water is not reduced. A seepage is caused often enough not only by rain-water which falls directly on refuse but also by waters that have access from the side. The pits turn into funnels and the drainage of unpolluted rain-water becomes extremely problematic. Rain-water drainage from pits presents an even more acute problem in rainy seasons. Basically, similar problems remain if the subsoil is made impermeable through special measures. Water retention layers are formed and refuse components are leached to a greater extent in this case as well, clogging drainage pipes.
All things considered, waste disposal on impermeable subsoil or subsoil made impermeable presents a wastewater treatment problem in either case. Even if the biological stage in wastewater treatment plants can easily decompose the organic components in percolating waters (lagooning should be rejected since it is ineffectual in winter), considerable quantities of nondegradable inorganic components remain and are thus discharged into the receiving water. Besides, the construction of a wastewater treatment plant poses a considerable financial problem. The tabulated pollution load in 2.2 calls for an investment of several million DM.

If refuse is dumped over porous aquifers point sources of pollution arise as a result of relatively small quantities of organic substances and, in most cases, an admissible salt concentration in groundwater **(Klotter & Hantge, 1969).***

In each case it has been shown that a certain degree of surface or groundwater pollution must be reckoned with.

On principle, however, the disposal of refuse in impermeable pits should be avoided if the underground aquifer does not slope to its lowest point beyond the landfill and if the drainage of unpolluted rain-water can not be guaranteed fully. Furthermore, biological treatment of percolating waters in a wastewater treatment plant and discharge into a receiving water-body should be warranted. Moreover, clogging of drainage pipes should be taken into account.

Therefore, measures aimed at reducing further the quantity of percolating waters which would consequently diminish the amount of leached out refuse components are of particular importance when depositing refuse in porous fills. Since subsoil sealing poses problems, one should prevent rain-water from penetrating into the mass of refuse at all costs. The following measures are possible:

a) The refuse surface should run in a slope from the centre of the fill to the edge of the pit. The creation of such refuse berms should be realized in accordance with the environmental authorities in order to fit them into the recreation programme of the respective municipality. One of several examples is the "rubble mound".

b) Since plants are known to absorb water it is advisable to grow grass and flat-rooting shrubs over the fill.

c) Disposal of liquids and wet, non-dewatered sludges should be avoided if possible.

d) The refuse surface can be sealed additionally if necessary. Basically the same measures used for sealing the subsoil are also suited in this case (an approximately 50 cm thick layer of clay, loam or plastic material on a layer of sand). These layers are then covered with arable soil.

With the measures stipulated in a) to d), it should practically be possible to exclude a contamination of percolating waters and reduce the quantity of leached out refuse components to well under 1 % of the total amount. It is necessary, however, to deposit refuse lot-wise and not over a large area. This measure should prevent the seepage of rain-water through the mass of unprotected refuse and the forming of percolating waters during the operation of the fill. Percolating waters are not formed directly after refuse disposal, since the moisture content of refuse ranges from 17 to 45 percent by weight and percolating waters are formed only at a moisture content of over 67 % (according to their own tests). These figures refer to "fermenting" refuse from a sanitary landfill.

The difference in cost between surface and subsoil sealing is very small. The construction of a costly wastewater treatment plant is thus unnecessary.

As a result, refuse disposal on impermeable subsoil requires special consideration and measures. Sealing of the refuse surface should in future replace subsoil sealing. The quantity of leached out materials will thus be reduced and the construction of a wastewater treatment plant made superfluous.

With regard to surface and groundwater pollution control, this measure is altogether more effective and cheaper.

* Klotter, H.-E. & Hantge, E.: Abfallbeseitigung und Grundwasserschutz, Müll und Abfall 1 (1969), 1–8.

Periscope

India

This is a summary of a paper entitled "Elevated Temperature Technique for Enumeration of Salmonellae in Sewage" by P.M. Phirke of the Division of Microbiology, National Environmental Engineering Research Institute (NEERI) in Nagpur, India.
This paper was published in Indian Journal of Medical Research, Vol. 62, 6, June 1974. It describes an elevated temperature technique for enumeration of salmonellae in sewage and sewage effluents by "MPN" method using selenite brilliant green (SBG) broth and an incubation temperature of 41.5°C. For the purpose of evaluating this elevated temperature technique and comparing it with the one using conventional temperature of 37°C., 17 different sewage samples were analysed for **Salmonellae** using both the techniques. The results obtained are reported and discussed. The elevated temperature technique yielded consistently better recovery of **Salmonellae.**

Abstracts

The following abstracts have been taken from our documentation on solid wastes which contains at the present moment over 2500 publications.

Hunt, J.W.: Special guidelines for operating a sanitary landfill, 1973, 36, No. 2, 113–123, Journal of Environmental Health.

Some special guidelines and criteria for the operation of a sanitary landfill are presented. Planning, developing and operating a sanitary landfill are discussed, including consideration of drainage, preparation of berms, trench operation, area fill, choice of equipment and equipment maintenance. Special attention is given to the handling of potentially troublesome items that may need special attention, such as galvanized water tanks, butane or propane tanks, incoming hot ashes, established fires, bundles of wire, bedsprings, and discarded tires.

Kasper, W.C.: Power from trash, 1974, 16, No. 2, 34–38, Environment.

Large amounts of urban refuse, instead of becoming an increasing waste disposal problem, can provide a low cost and low polluting fuel, particularly to run electric utilities. Methods both technically feasible and economically sound have been developed to use the potential heat in solid waste. This paper outlines various processes that have been developed to provide a new approach to the problem of disposing of the constantly increasing quantities of solid wastes. The main emphasis of this paper is to describe and compare those processes which would most likely be operated by or in conjunction with an energy supplying utility.

Answers to Pollution Puzzle

1 B	2 E	3 E		4 P	5 U	6 R	7 G	8 E		9 G	10 O	11 A
12 E	E	C		13 E	T	H	Y	L		14 N	A	G
15 S	L	U	16 D	G	E		17 M	A	18 N	U	R	E
			19 U	S		20 S		21 M	I			
22 A	23 L	24 A	S		25 G	U	26 T		27 B	28 A	29 L	30 E
31 F	I	L	T	32 E	R	P	R	33 E	S	S	E	S
34 O	N	I		35 L	A	P	E	L		36 T	R	E
37 R	E	C	38 O	M	P	O	S	I	39 T	I	O	N
40 E	N	E	D		41 Y	R	S		42 I	R	I	S
			43 O	44 E		T		45 M	T			
46 H	47 E	48 A	R	T	49 H		50 B	O	I	51 L	52 E	53 R
54 O	M	S		55 N	O	56 R	I	A		57 A	R	A
58 P	U	P		59 A	G	E	N	T		60 B	A	T

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