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Wealth From Waste.

By

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Let me in the first place thank the President and members of this Union for having done me the honour of asking me to preside on this occasion. I cannot claim to be an agriculturist but I do claim to be a chemist, intensely interested in agriculture, and I think you will agree that agriculture is becoming more and more a branch of applied biochemistry. Deeper, however, than my scientific interest in agriculture is my desire to see, if possible, some mitigation of the ills of India through the application of scientific thrift to the uses of agriculture.

You will all probably have seen the statement by Sir James McKenna that the waste that is going on in India is "simply colossal." He holds further that no other country in the world could stand such waste of available raw material and that great responsibility rests with all concerned to put an end to it. I hope that on this occasion we may together try to face this responsibility.

I propose to consider first the utilisation of the waste materials of the farm and country and afterwards those of cities and towns.

As a beginning I will ask you to look at two pictures on the screen, the first represents a bed of hollyhocks planted practically unmanured in the ordinary simple fashion of the Indian *mali*. You will see that the plants are sparse and spindly, only here and there rising to a height of 3 feet or so. In the second picture there is a bed of massive plants 12 feet high, loaded in fact with deep coloured flowers and constituting a magnificent sight. I regret that I can only show you the quantitative effect in the photograph. This extra ordinary difference was brought about without any expenditure of actual money but solely by the use of well directed labour and scientific application of waste materials, leaves and grass from the garden, rotted down by methods easily learnt by the illiterate. The soil had been thoroughly dug and carefully mixed with the compost which had itself been reduced to a fine powder by rubbing through a sieve, the result you see. I could show you pictures of cannas equally luxurious.

Substitute for the hollyhocks and cannas, wheat and consider the addition to the nation's wealth. In their little volume of condensed experience on Indian Agriculture, recently published, the Howards write concerning wheat.

> "At the moment the most pressing problem in wheat production in India is the spread of intensive cutivation coupled with reduction in the volume of irrigation water used in raising this crop. Ground has been broken in this direction. When the amount of organic matter in the soil is increased yields of over 30 maunds to the acre have recently been obtained with only one watering".

I have myself seen fine crops of wheat growing at Indore on land only recently barren but converted under Mr. Howard's instructions into well drained rich soil.

To obtain this result, in the first place the land is broken up and the weeds extracted not by employment of heavy and expensive tractors but by the simple expedient of training oxen to "form fours." In this way deep-rooting grasses can be removed, the land cleaned and the soil can be cultivated to a depth of 8 inches without soil inversion. Weeds when brought to the surface can be rotted down to compost and so a pest is made into an asset.

With the increase of crop resulting from improved methods, increase of straw and trash is obtained and the manure supply automatically increases.

Much work is now being done all over India, I am glad to know, on the scientific preparation of artificial farmyard manure from the ordinary refuse of the farm. I have dealt with the scientific research at the back of this work in my address to the Indian Chemical Society at Madras last January so that I need not enter into details here.

It is important, however, to emphasise certain broad principles.

The work of Richards and Hutchinson at Rothamsted showed us all the principles which must be followed if the preparation of artificial farmyard manure is to be successful. They showed that there must be a defined ratio between the nitrogen and carbon in the raw materials used. They found that the organisms responsible for the breaking down of straw and other carbonatious material function best in the presence of air and further that the nitrogenous matter must be applied at suitable concentration and under neutral or slightly alkaline conditions.

Just as in the allied problem of sewage purification it has been possible greatly to accelerate the speed at which reactions take place by the production of a suitable "*activator*" so the efforts of some of us have been directed to find out the conditions under which artificial farmyard manure or "*compost*," as it used to be termed, can be produced in the shortest possible time. This aim, it can be seen from their published papers' was also present in the minds of the original workers but does not seem to have been very actively followed up. To sum up the result of the work so for done at Cawnpore we find that compost is most rapidly made if the materials are cut either by hand or in a chaff cutter into small pieces and first of all thoroughly rotted down with a mixture of cowdung and cow's urine applied in a thin decoction so that every portion of the mass comes in contact with the inoculant and fermentation takes place evenly in consequence throughout the mass. On piling in a heap not more than 3 or 4 feet high and turning over from time to time, keeping moist with the same decoction, very high temperatures are attained which destroy all insect larvae. When the temperature begins to drop a further quantity of chopped raw material is added to the heap which now becomes the "activator." About 25 percent only of new material should be added at one time and thoroughly mixed with the activator, the cow dung and urine decoction being added at intervals as before. The method, obviously, can be readily systematised. At one end of a long heap is the finished rotted material which can be dropped, if necessary, into a pit to be stored until required and at the other end is the new material. The formula given to the mali is 2 old and 1 new i. e , a given heap of the finished material is divided into three parts one, part sent to store, the other two parts mixed with one part of partly rotted raw material and so on.

Instead of cow's urine it is possible to use other materials such as sulphate of ammonia, ammo-phos etc. Calcium cyanamide for some reason is not so satisfactory, possibly because of its inhibiting effect on nitrification as pointed out by Walton in a recent Pusa Memoir.

There is no doubt whatever that apart from nightsoil which is specially effective, cow's urine is the best material to use in making composts and every care should be taken to conserve this precious source of nitrogen.

It is strange to read in the number of the Agricultural Journal on India for May 1929 which has just come to hand that even in Great Britain the value of cattle urine has to be insisted upon. It is not only in India that scientific knowledge takes some time to reach the farmer. More than 15 years ago with the assistance of a grant from the Board of Agriculture through the good offices of Mr. (now) Sir Thomas Middleton of the Linlithgow Commission the whole question of the use of liquid manure was carefully studied in England by Manchester workers and presumably the reports are still in the pigeon holes of Whitehall.

In the recovery then of the waste litter of farms and garden leaves, weeds, straw etc., as well as cow-dung, urine we have a striking example of the utilisation of one form of waste material for the benefit of agriculture. The Government Farm at Dacca for the first time in its history, we are told, has had in this way an adequate supply of manure. At Indore thousands of cartloads of such manure have been applied to barren soil with the result of a constant increase in crop.

It is some times argued, and in any event practice implies the assumption, that all this artificial preparation of composts is unnecessary and that the raw material can be simply applied to the soil and be allowed to rot there. Biochemical science and the experience of thousands of years of Chinese agriculture contradicts such an assumption. Again to quote from Howards' book page 45.

" The partical problem is to prepare a supply of fermented organic matter and to apply it to the soil at the right moment. In this matter the Indian cultivator has much to learn. His

> scanty supplies of manure are allowed to dry outside the house and are applied to the land in an undecayed and unfermented condition. After the seed is sown, the soil has to prepare this undecayed material at a time when all its energies should be devoted to providing the plant with food materials. Both these processes require large volumes of oxygen and thus compete for a substance likely to be in defect. The result is over-work and fatigue. Crop-production really consists of two processes which are best kept separate : (1) the preparation of food materials which should be done outside the field and (2) the growth of the crop-the real work of the soil. The Chinese were the first to discover and to adopt this master idea. They go to infinite trouble to convert all sorts of refuse animal and vegetable matter into finely divided manurial earth ready for the use of the crop."

I shall have to refer again to what is here termed the the "master idea" of the Chinese when speaking of the utilisation of another kind of refuse.

Almost all kinds of vegetable matter can be utilised for the preparation of these composts. In Cawnpore we have made use of the miscellaneous weeds which grew up on a local Golf course as well as plantain stems, sun hemp, and *pluchia lancesla* which is best utilised in its early stages of growth before the stems become lignified and which grows in vast quantities over many tracts of country.

Mr. Youngman at Nagpur has been able to utilise cotton stalks as manure by chopping them down into short lengths and allowing them thoroughly to soak in water before undergoing the fermentation process.

The utilisation of oil seed cakes has received much attention and greatly improved results can be obtained with a little scientific attentton to the preparation of the material.

Water hyacinth can be readily composted with much resultant benefit from its high potash content.

All the foregoing materials have been referred to simply as possible ingredients of manurial composts. By more advanced technology, products of even greater value can be obtained from many of the waste materials of the country side and it will be of interest if we consider a few of these.

Water hyacinth :—Is a well known pest in the waterways and tanks of Bengal and also in certain districts of the United Provinces. Its use as a source of potash for agriculture by the simple method of composting has just been referred to.

Professor H. K. Sen of Calcutta has shown, however, that very pure potash salts can be extracted from the plant leaving the organic portion intact.

Prof. Sen has published the results of expriments and calculations which indicate that alcohol can be profitably obtained from the organic material of the plant.

My own view is that after extracting the potash by Prof. Sen's method it will be more technically practicable to ferment the vegetable residue to power gas consisting largely of methane and hydrogen. I am told that the youth of Bengal amuses itself sometimes by collecting the gases which bubble from the bottom of tanks infested with water hyacinth. Here we have evidence of the possibility of the necessary fermentation.

In the Septic tanks which used to abound on the banks of the Hooghly I found in 1906 copious evolution of marsh gas and at that time a small engine was actually driven from the gases produced from the Septic tanks at the Leper Asylum at Matunga near Bombay.

I have long been interested in this problem and a good deal of work has been done and published from Bangalore but the first large scale success is now reported from Birmingham. At the great sewage works of the Birmingham Tame and Rea District Board, Mr. O'Shaughnessey, the Chemist of the Board has for a long time been studying the bacteriological digestion of sewage sludge which contains large quantities of cellulose from which by anaerobic fermentation is produced marsh gas and hydrogen. In a recent paper by Messrs. Vokes and Townsend on the Engineering Staff of the Board, a description is given of the works which have been installed for the collection of this gas from the 400,000 tons of crude sludge which has to be dealt with annually. Briefly the gas is collected from the sludge digestion tanks by means of floating concrete gas collectors of special construction. Sufficient gas is now obtained to run economically an engine of a 150 B. H. P. but it is anticipated that the power available from the gas hitherto liberated into the atmosphere is about 1100 B.H.P. continuously night and day. The quantity of gas is about

150 million cubic feet per annum, its value at 1s. 6d. (one rupee) per 1000 cubic foot is about £. 11,500 per annum.

The sewage sludge of India, as I hope to show you later, is much better employed in fertilising the land than in running gas engines, but I see no reason why the vast growths of water hyacinth in Bengal and elsewhere should not be fermented in this way and the gas converted into power. If this can be done efficiently it will be almost the quickest method of direct conversion of Solar energy into power that I am acquainted with. Experiments are being carried on at Cawnpore from which I have considerable hopes but the conditions are not altogether simple and it is too early yet to do more than draw attention to this great possibility.

If some one was to find oil under the ground in Bengal it would be looked upon as a means for industrialising the country and no one would be alarmed at the cost of piping the oil hundreds of miles if necessary. Why then should not water hyacinth be fermented to power gas and the power gas converted by gas turbines if necessary into electrical energy for the benefit of local industry.

I have spoken of the use of oil seed cakes as manure. There are however other uses possible to the advanced technologist. We hear from the United States of the utilisation of groundnut husks for slab tiles and fibre concrete and attempts are being made to convert them into rayon and paper though these have not yet been successful. A systematic study should be made by thoroughly competent chemists of the possible uses of the waste material from seeds of all sorts.

We hear that Quaker Oats is only one product among many from this cereal, one of the chief accessory products is furfurol, a valuable solvent.

More than fifty chemical products can be obtained from corn cobs, and from cereals af all sorts are now being made butyl alcohol, acetone and numerous other solvents by controlled fermentation. These developments so far as India is concerned are rather for the future, although many hundreds of tons of butyl alcohol and acetone were made at one time at Nasik. The first thing we have to do is to handle the simpler problems.

My colleague Mr. J. A. Hare Duke, Oil Expert to the U. P. Government, has recently been experimenting with linseed stalks, a waste product of the linseed oil industry. He has obtained a fibre which he assures me is more than the equal of jute. Basing the value of the fibres at about half that of the lowest quality Russian flax and basing the yield of fibre at 3 maunds of good fibre and 3 maunds of tow per acre it would appear that at present India is annually throwing on the manure heap from linseed alone, fibre and tow of the value of well over six crores of rupees. I have here a sample of the linseed fibre for your inspection. It is true that the conditions of growth of the plant are somewhat different according to whether it is being grown for seed or for fibre, but there is no reason why even when the plant is being grown primarily for seed the fibre should be entirely wasted.

As I have mentioned publicly on more than one occasion there is a great possible market in Europe for tomatoes which with reasonable care can be produceed quite freely in various parts of India. The simplest method of marketing tomatoes for consumption out of India is as peeled tomatoes in tins. This yields a large quantity of tomato skins which by suitable treatment can be converted into quite a useful chicken food, and so we come to consider the question of egg production for which there would seem to be an unlimited market, especially since the troubles in China have disturbed the supplies from that quarter.

There was during war time, among the Belgian refugees in England, a lady who had been accustomed to run a large Poultry Farm from which she produceed by scientific methods not less than one million eggs per annum. I remember she was explaining her methods to a friend of mine in rather valuable French English which he had some difficulty in following. When he asked her to speak more slowly, she replied, "But if you want to produce one million eggs a year you must be queek!" There is no doubt that her remark contained a powerful truth which the Indian agriculturist will have to live up to. If you wish to produce an adequate amount annually of eggs and make a living thereby you must be "queek." As Mr. Ford has put it in his autobiography :—

"If to petrify is success all one has to do is to humour the lazy side of the mind but if to grow is success then one must wake up anew every morning and keep awake all day."

I have here a picture of an Egg Farm at Los Angelos. You see in front of you 100,000 eggs which is only 3/4ths of what this farm produces daily. There are 300,000 laying hens and 200,000 baby chicks, thirty million eggs are exported annually. The food bill has to pay for a million pounds of varied diet, it is stated, to keep these gravel scratchers going. Among the articles of chicken food mentioned are sunflower seeds and I believe that there are great possibilities in the cultivation of this easily grown plant if all its bye-products are utilised and not wasted.

Before we leave the country for the town mention should be made of the great waste due to ***kutcha*** roads. Any one who has to visit a distant village off the beaten track will soon have experience of the waste of time and energy due to kutcha roads. Even in the more public highways the rough and ready methods used for temporarily patching roads are very largely a simple waste of public money. Howard suggests also that if the narrow wheels usually fitted to bullock carts can be replaced by stronger wheels with broad iron tyres roads would last longer and break-downs would be far fewer than is now the rule. The loss of man and cattle power due to the collapse of cart wheels on the main roads to large cotton market towns must run into thousands of rupees annually.

To sum up then, apart from all these incidental possibilities the results of intensive cultivation alone show at Shahjehanpur that by the use of adequate manure and water the yield of standard crops such as wheat, gram and sugar cane can be more than doubled as compared with the yield of the ordinary cultivator.. More striking figures even than these can be given and it is clear, as Howard states, that in the Punjab and the U.P. alone crores of rupees worth of potential crop production are literally thrown away.

To come now to the second portion of our subject the waste from towns and cities, the main waste materials which we have to consider are (1) Towns' Refuse, and (2)Human excreta.

Considering first Towns' Refuse, the composition of this will vary to some extent according to the season and according to the district and the product of Indian towns is quite different from that which is met with in richer countries. In the United States where there is considerable waste of food, towns' refuse often contain a good deal of fat and before any further treatment it is usually submitted to a rendering process to get out this valuable constituent.

In India so far as my observation goes towns refuse consists mainly of straw and paper and the ordinary sweepings of streets together with a good deal of mere dust. It is often intermixed with a certain amount of night soil and cowdung and consequently has a certain value on this account. At Nasik with a population of nearly 40,000 some 85 cartloads of sweepings are removed daily to the Municipal Depot. Experiments indicated that this material could be rotted down to an excellent manure by a systematic fermentation with cowdung or night soil in the manner I have already described.

The problem of the disposal of this kind of refuse in large cities like Bombay and Shanghai is becoming very serious since in virtual absence of unburnt household ashes such as used to be present in pre-war refuse in English cities disposal by incineration is not likelyto be profitable.

In general it seems to me that the best method for dealing with kutchra would be to submit it to a double-screening process, i. e., in the first place to remove large objects such as old tin cans and pieces of glass and metal. The material passing through this open screen should fall on to a second and fine screen through which will pass the dust which can be used for rough concrete or similar purpose. In this simple way the organic material present will be concentrated and can then be scientifically fermented in the manner already described.

Since writing this paragraph I have noticed in the latest number to hand of the Journal of the Society of Chemical Industry that reference is made to processes patented in Italy for dealing with town's refuse on lines apparently very similar to those I have suggested.

We now come to the very important question of the enormous waste involved in the non-utilisation of the manurial value of ***night soil*** and ***sewage*** :—The figures given indicating the possibilities if this material were fully utilised are almost unbelievable. In the very interesting volume " Uses of Waste Materials " compiled by Prof. Brttuini and published by the International Institute of Agriculture at Rome very full statistics are set out on this subject showing the value of the sewage from most of the capital cities of the world. Among them Delhi is men tioned and it is stated that the nitrogen derived from its population of 282,000 is sufficient to fertilise a minimum of 10,000 and a maximum of 95,000 acres according to the dose given. Consider what this means for all the towns in India.

When we consider that a very large proportion of this material is either simply wasted in India or worse than wasted in that it is allowed to become a centre of disease breeding infection by flies and in other ways, we shall realise the wisdom of a recent utterance of Mahatma Gandhi who states that "Indians are clean as individuals, but not as members of the Society or the Nation of which the individual is but a tiny part." "He observes that "corporate insanitation is not the least of the diseases to which India is subject."

Anyone whose duty it is to look into the sanitary disposal of town waste must agree with him.

Of the village the sage of Gurgaon says " There is very little manure in the fields, but plenty of filth in the village and on the children. Do you think that by manuring your children they will grow better ? "

It is true that the problem of the sanitary disposal of human waste has been one of increasing complexity but I hope to show you how by the most mòdern method known as the *Activated Sludge Process,* all this waste abomination can be rapidly transformed into clean and valuable products by a simple process of scientific aeration.

Before discussing this important subject in detail it will be well if we have a clear idea of the main constituents of the sewage which has to be purified. These constituents can be broadly divided under the following heads :—

1. Soluble matters,

2. Colloidal matters.
3. Matters in suspension.

An ordinary sample of sewage taken in a bottle has tne appearance of a grey turbid liquid, from which about half an inch of dark grey deposit will generally settle. The turbidity is caused by the colloidal matter, by which we mean very simply, sticky substances which are not entirely dissolved nor yet entirely in suspension, and which are exceedingly difficult to deal with, since they clog up the surface of land or of artificial filters. The colloidal matters in sewage are mainly derived from the churning up of foecal matter in the sewer.

The matter in suspension which settles down at the bottom of the bottle, consists of sand and other mineral detritus which mechanically retains a certain amount of sewage matter.

In solution are the soluble salts of ammonia which are mainly derived from urine.

If this unpleasant mixture is allowed to remain in absence of air it undergoes putrefaction with production of evil smelling substances and hence arises the sewage nuisance.

We may enquire how is it that with the immense quantity of waste products of human life produced day by day there is not an overwhelming catastrophe. The answer is that Nature has provided her own scavengers in the form of minute organisms known as bacteria. These are so small that were one of them to be magnified to the size of a man and the man magnified in proportion, the magnified man would reach from Bombay to Calcutta. Although these scavengers are so minute fortunately there are immense numbers of them and so the work gets done.

Some bacteria work in absence of air and generally give rise to nuisance and putrefaction. The bacteria which are most useful in sewage purification are those which work in presence of air or oxygen, which is available either in the interstices of the soil, or dissolved in water.

The ordinary domestic cat has a thoroughly scientific knowledge of sewage disposal, carefully burying its excreta in the soil and what is more, instructing its children to do so. Once buried in the soil the offensive matter is dealt with by the bacteria everywhere present in fertile soil, and converted into harmless nitrates which are soluble crystalline salts, and into the brown humus characteristic of good fertile soil. The nitrate deposits found on the sites of old abandoned villages are obviously derived from old organic matter.

The same process can be seen going forward in rivers and streams which are subject to sewage pollution, provided enough oxygen is present in solution to oxidise the sewage. Careful observation will show that under these circumstances the original turbidity gradually tends to clot and the liquid to become clear, the clotted particles gradually settling down and forming a brown inoffensive mud on the bottom. This is what actually happens to sewage when it is discharged into an estuary or into tidal waters. In a case in which I was concerned many years ago it was contended that inasmuch as no nuisance could be proved the discharge of sewage into the estuary under discussion was entirely harmless, and it was even supposed that all the sewage matter had been converted into soluble or gaseous constituents. The observations of the Harbour Engineer, however, indicated the existence of considerable deposits of brown humus in the bed of the channel so that mere discharge into the sea is not necessarily the end of the matter, quite apart from the waste of fertilising material involved.

The activated sludge process is simply an adaptation of Nature's methods, so adjusted and developed as to obtain the maximum results, in the shortest possible space of time.

If air is allowed to bubble through a sample of sewage a number of changes progressively take place. The first to be noticed is the gradual conversion of the colloidal matter which gives the turbid appearance to the sewage, into brown granular particles which readily settle leaving a sparklingly clear liquid. In course of time nothing is left in solution but mineral salts, viz , chlorides and nitrates.

This complete oxidation of sewage by the action solely of air in conjunction with the bacteria originally present in the sample of sewage, occupies a considerable time, possibly many days, and for this reason purification of sewage by aeration alone was long deemed impracticable. It has been found however that if the brown granular deposit which forms is allowed to settle out from the liquid and the latter decanted away and a further quantity of sewage aerated in contact with the brown deposit and this process repeated, the brown deposit being retained at the end of each operation, then as the quantity of the deposit increases the time required for the purification of the sewage decreases. Finally when the deposit has accumulated to the extent of about a quarter of the total volume of the sewage the latter can be purified in a few hours time and the process becomes a practical proposition. The brown deposit has been termed '*activated sludge*'

For the practical carrying out of the activated sludge process artificial aeration is necessary and the sewage needs to be freed from heavy detritus and from floating solids, that is to say it requires in general to be passed through a system of catchpits and screens before the aeration process.

Briefly the process is carried out in practice as follows: The screened sewage passes into a long narrow aeration tank into which air is forced in a state of fine division. It has been found that this fine division is necessary for the sake of economy of air and it is effected by the use of what are known as diffusers of porous material through which the air is forced creating a fine emulsion of air and sewage. The efluent passing away at the end of the aeration tanks is purified but contains, of course activated sludge in suspension which must be separated and returned to the inlet of the tank. The aeration tank is therefore followed by a settlement tank in which the activated sludge rapidly settles out and from which the clear and purified effluent passes. The deposited activated sludge can be lifted from the bottom of the settlement tank by means of compressed air either back to the inlet of the aeration tank or out of the system altogether on to sludge drying beds from which it can be removed and used as manure. Any surplus over and above the 15 or 20 per cent of the volume of the tank which is necessary to effect purification is thus removed from time to time. The whole installation occupies very little space. The sewage e.g., of 100,000 people can be purified in tanks holding a million and a half gallons, that is a space of 300 feet by 100 feet by 8 feet. In addition buildings will be required to accommodate machinery for air compressing and possibly sludge pressing and drying.

To purify under European conditions the same quantity of sewage to an equal extent by means e.g., of septic tanks and percolating filters, would require approximately double the tank space and in addition 6 acres of percolating filters 6 feet deep.

The activated sludge process has passed far beyond the experimental stage in the usual sense of that word. That every problem has been solved cannot be said of activated sludge any more than it can be said of human nature itself, but at any rate a great many initial objections have been overcome and the process has shown itself to be one capable of purifying sewage efficiently and at a reasonable cost. At one time it was suggested that blowing air into sewage must necessarily cause nuisance. That nuisance is caused when sewage putrefies in absence of air is well known but aeration in presence of activated sludge completely eliminates offensive odours as can be seen by the photograph of the tanks now in operation at the Madura Mills, Tuticorin which are situated immediately under a latrine serving 2,000 people. A slight smell is necessarily present where the fresh sewage enters the tanks. This can easily be got over by covering up the inlet When once the sewage has met the activated sludge there is no smell whatever and it is possible to walk about in the space shown in the photograph without experiencing any unpleasantness. The effluent passes away from the tanks as a clear sparkling stream entirely odourless. At the Hague an installation is situated immediately under the windows of two dwelling houses. It has been there for many years without causing trouble.

To come now to the interesting subject of the fertilisng value of activated sludge, this from the first has been shown to be quite exceptional, not only is there a high percentage of nitrogen and phosphorus but these elements are present in organic combination and in forms specially suited for plant food. The two pictures of pot culture, shown on the (screen) show trails which were made in the early stages of activated sludge research, in the first is shown a series of pot cultures with equal quantities of nitrogen. The growth in the pots receiving activated sludge is altogether out of proportion to the others. Similarly the Azalea in the next slide show the wounderful effect on the bloom by a dose of activated sludge.

I am told by the P. W. D. Engineer at Ambernath, where for some years a little installation was in operation, that he has obtained marvellous results with roses.

Hitherto the difficulty with activated sludge has been the drying of the material for transport, it is of a jelly-like nature and holds water very tenaciously. In Prof. Bruttini's book published in 1923 speaking of activated sludge he says " up to the present the difficulty of eliminating the 98 per cent of water from the activated sludge resulting from the process of sedimentation has not been overcome." That cannot be said to be the case today. At the great works in Milwaukee a photograph of which you have seen the sludge is being handled by band filters and rotary driers in such a way as to obtain a saleable product at not too great a cost and the latest information is that they have a forward market for the resulting dried sludge which has been given the name of " Millorganite," to the value of £.100,000 per annum, the dried sludge being worth on rail at the works the equivalent of Rs.45.

The methods used for drying at Milwaukee, so far as one can judge from the somewhat scanty details published, may be described as simple but brutal; one hears e.g. of temperatures up to a 1000°C being used. If this is the case it would seem certainly to result in overheating of the sludge with detriment to its special qualities as a plant food. I am now in a position to show you a more recent process which I venture to think will be very much less costly and will result in a product of a greater manurial value. The process depends on the utilisation of the physical effect of innumerable up turned fibres in causing water to drain away rapidly from wet mud. Every one knows that an ordinary tent will give protection from the rain so long as some foolish person does not touch the canvas with his fingers when immediately a stream of water begins to run through. The idea of a filter mat is to multiply these fingers so that excess water very quickly runs awy from a thin layer of sludge spread upon the mat. Moreover if the sludge is at the same time heated then the jelly which I have spoken of is broken and the water again quickly runs away and has to be evaporated as in the Milwaukee process.

The sludge is fed on at one end of a slowly rotating mat and meets a stream of hot air passing in the opposite direction. Experiments at Cawnpore have shown that with air entering at a temperature of 200°C a thin layer of sludge on the surface of the mat can be dried in 10 minutes. It is true that the layer must be very thin but if you consider an ordinary paper making machine, wet pulp is fed on to a moving mesh in a thin layer, and gradually appears as a roll of paper at the end of the operation. You will see that the constant production of small quantities, minute by minute, results at the end of the day in quite a large outturn. If the preliminary small scale results can be confirmed by working experience it would appear possible to dry the sludge corresponding to a population of 50,000 or half a lakh of people by a machine which with its accompanying air heating arrangements and so forth will occupy a space of not more than 400 square feet.

There is every likelihood that the process will come to be even more economical than the construction of sludge drying beds from which the water only drains away, as a rule, very slowly.

When the Agricultural Commission visited Cawnpore, Lord Linlithgow showed a great interest in the activated sludge process, but he told me that he was concerned as to the possibility of conveying infection if this material was transported from one part of the country to another. By the process which I have described, the details of which have been worked out since the visit of the Commission, the heating while not sufficient to spoil the quality of the sludge subjects it to a temperature high enough, to destroy all such organisms as hookworm, even supposing these to be present.

I understand, however, from Col. King of the Guindy Institute that he has found means for eliminating these dangerous parasites from a septic tank by a special design of inlet, so that we may hope that they may be prevented even from entering the activated sludge tank.

A very important and critical point to study is that to which I have already referred in speaking of compost making, viz , the "master idea" as Howard terms it of the Chinese that food should be prepared for the plant before it is put into the soil, that the soil should not be expected to prepare the food and grow the plant at the same time.

Now the activated sludge process does for manure in solution, what the compost making does for solid material, it prepares it for the plant. I have dealt with this point in some detail in a section of a Bulletin of your Department of Agriculture, entitled "The Manurial Problem," which, by request of the Director of Agriculture, I had the honour to contribute.

The aeration of the sewage in the activated sludge tank is equivalent to constant tillage of the soil, and the consequent result is attained in a much less laborious and more efficient way.

Moreover, the effluent, if not required for irrigation can be stored without nuisance, and in such storage ponds fish can be grown as is constantly done in China and in many towns in Europe, or aquatic plants may be grown and afterwards used for compost.

You will shortly have an opportunity in the plant now under construction on this College estate, thoroughly to study these and many other local problems concerned with the activated sludge process. Unfortunately the constuction work was not completed before the monsoon came upon us, and flooded the excavations. I was in hopes that the process might have been put into operation about the date of this meeting. However the delay should not be very serious and I look forward with great interest to the research work both in sanitation and agriculture which may be done in connection with this plant.

From what I have been able to bring before you in the short time at my disposal I hope it will be seen that there are vast possibilities of increasing the wealth of this country if material which is at present wasted or worse than wasted is properly made use of. It would seem worth while indeed for a special officer to be appointed by every Government to obtain statistics of the available wealth producing materials in the Province which are at present being wasted and to stimulate and correlate their utilisation by officers of the various Departments concerned. Such a beginning has already been made in the Bombay Presidency and I have on my files a tabular statement of the receipts from the sale of kutchra and night soil actually collected in 32 towns of the Nasik district. On calculating the actual value of these materials and the price obtained there is a very great discrepancy showing enormous possibilities of increased returns if the matter was seriously taken in hand by the agricultural department working in conjunction with the sanitary officials, the whole work being as I have suggested correlated throughout the Province and ultimately throughout India. Thus, taking Nasik alone the value of its night soil, not theoretically but on the basis of what is paid by Chinese contractors in Shanghai, amounts to Rs. 35,000 annually, actually only Rs. 2,500 are received and no account is taken of the kutchra available. The necessity for such a systematic attack cannot be doubted, if any increase is to be made in the real wealth of India. It is becoming almost a commonplace that without a general rise in the standard of living, real industrial development in this country is hardly possible. In this connection I should like to quote from the Ditcher's Diary of *Capital* of March 14, 1929:—

> " Inasmuch as it is not possible to attain selfsufficiency in every sphere simultaneously, it is necessary to make a choice, basing the choice on some sort of order of economic precedence. In that event self-sufficiency in regard to food-stuffs would come first on the list.
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> The plea is not for abandonment of industrial expansion, but for simultaneous progress along the whole economic line. In the post-war period, however, while urban industries have expanded fairly rapidly, agriculture relatively, has made little progress,—the economic dislocation now visible representing the inevitable sequel. If less Indian money went to Java to buy sugar, to Australia to buy wheat, to Siam and Indo-China to buy rice, and to Europe, Aden and other sources to buy salt, there would be more money to buy Indian manufactures. At a moderate estimate, the sum so diverted this year will exceed 30 crores of rupees—an amount probably adequate to purchase the total yearly output, working to full capacity, of all the Bombay cotton mills combined. It would be as futile to endeavour to burke these facts as it would be to try to escape the inevitable conclusion. Deficient purchasing power is indubitably the chief hindrance to larger outputs and sales of Indian manufactures, and, to no slight extent, this deficiency is traceable to import-

ation of food-stuffs which India, by more efficient methods of cultivation, might produce from her own soil. Better work in the fields would mean fuller employment, and larger profits, in the mills. As it has been truly observed :—

> " Modern industrialism, based in India upon a primitive system of agriculture, rests upon a foundation too narrow and unstable to permit of full development. A low net profit in the fields means low dividends and low wages in the factories. The interdependence is complete and inescapable."

The argument is frequently used that even supposing that Milwaukee does produce £ 100,000 worth of activated sludge per annum, it costs a lot of money to get it. True, it also costs a lot of money to keep alive. Really, to save money the best thing would be to die. It costs little to lie in the grave. And indeed that is the alternative. It costs little apparently to allow human excreta to fester in the streets, and to poison the wells and watercourses.

In Milwaukee formerly the sewage used to flow into Lake Michigan from which the water supply of Milwaukee and other cities is derived. The expenditure on the great works I have referred to means an enormous reduction in the risk of water borne disease. The money too has largely passed into salaries and wages of intelligent and educated mechanics, engineers and chemists, who also find employment for others in the spending of their salaries. The sludge which used to defile the bright waters of the lake now reappears as wheat on the wide acres of western prairies, or as smooth rich turf on countless golf greens. Surely there is profit and true wealth in all this.

Here in India how many offices and factories run a whole month without absences due to sickness? What is the average expectation of life of an ordinary citizen in the bazaar, let alone the babies, perishing from infantile diarrhoea and other filth caused diseases? Let the Directors of Public Heath tell us.

It is true it costs money to be clean, but the interest comes back a hundred fold in more and better employment than that of sweepers, striking as they have been in Nagpur and elsewhere for some increase in their monthly pittance. Let this labour be put to better use on the land, let employment be found for the students of our engineering and agricultural colleges, and this expenditure will have as its result, health and happiness, instead of disease and misery.

How often it has been said to me when discussing possibilities of improvement, "That is all very well but India is too poor." India does indeed suffer from what in the jargon of present day psychology is termed a deep seated "poverty complex", which is due not to fate or to foreign rule but to ignorance, superstition and inertia. It is for the students of such Colleges as this in which we are here assembled to spread the enlightenment which they have received within these walls and on these fields to their less fortunate brethren in the scattered villages all over the Presidency. It is not an impossible task, Gurgaon, Indore and the demonstration vans of your own Agricultural Department have shown the way. Good humour, kindliness, energy deep and whole-hearted sympathy and desire for better things will in due time cause to arise that new India which is present in the mind of every man of good will.