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DATED 10th May 1895.

[Despatch Abstract.]

Madras Sewage Farms.

Communicating to the President, Municipal Commission, Madras with remarks, the memorandum of the Sanitary Commissioner in connection with sewage-farming in Madras.

GOVERNMENT OF MADRAS.

LOCAL AND MUNICIPAL DEPARTMENT.

READ – the following papers :—

From Lieutenant-Colonel G. M. J. MOORE, C.I.E., President, Municipal Commission, to the Chief Secretary to Government, dated Madras, 3rd December 1894, G. No. 495.

With reference to G.O., dated 26th October 1894, No. 2189 L., Local and Municipal, I have the honour to forward the accompanying letter from the Health Officer together with the paper referred to therein.

2. It is unnecessary for me to offer any remarks on what is purely a professional matter, except to say that the storage capacity of the wells will be increased, so that there may be no overflow of sewage at night.

ENCLOSURES.

From Dr. J. NIELD COOK, Health Officer, to the President, Madras Municipal Commission, dated Madras, 27th November 1894.

Concerning the comments on the Madras sewage farms contained in the annual report of the Sanitary Commissioner of Madras for 1893, referred for report in G.O., dated 26th October 1894, No. 2189 L., Local and Municipal, I have the honour to offer the following remarks.

2. In the few lines devoted to the subject the Sanitary Commissioner inferentially expresses very decided opinions. As I am unable to accept his conclusions and a mere expression of my opinion is not likely to weigh with Government against that of their own Sanitary adviser, I beg to submit a copy of a paper written for the Indian Medical Congress, in which I have dealt with the matter at some length (*vide* pages 6 to 7).

3. I consider that under-drainage is unnecessary, as the ground is perfectly permeable and the purified sewage will not cause pollution, and that the discharge of the effluent from the proposed drains is impracticable in the case of some of the farms on account of their levels. Discharge of sewage into the Cooum only occurs in the case of some of the smaller farms principally at night when the picottahs cannot well be worked. The amount is not large, as much less sewage flows at night than during the day. The Commissioners propose to deal with it by providing cisterns or storage tanks into which the sewage can flow until pumping is recommenced. The objection to this is that in a hot climate sewage rapidly decomposes, so that there is likely to be some nuisance from the stored sewage. I am unaware of any such thing as disposal by soakage in connection with the sewage farms. Any soakage which occurs is in consequence of faulty drains. If it were not for the presence of sewage farms in inhabited areas, disposal by discharge into the Cooum and by soakage would be the rule rather than the exception. With the introduction of a good system of sewerage capable of carrying all the sewage to the north of the town, the disposal of it could be arranged for by the extension of the Black Town farm and the difficulties now experienced would disappear.

Sewage Farming in Madras and the suitability of the system for India—By J. Nield Cook.

How to dispose of sewage has always been a problem of paramount importance. I do not propose to discuss the laws of Manu or Moses or matters of ancient history. For my present purpose sanitation may be said to have commenced in the latter half of the century. In 1857, the Royal Sewage Commissioners laid it down as an axiom that "the right way to dispose of town sewage is to apply it continuously to land." However, considerable difficulties were experienced in putting the principle into practice. The heavy soils found in most parts of England, the abundant rainfall throughout the greater part of the year, the low temperature during the winter months when vegetable life is practically at a standstill, and the difficulty and expense of acquiring suitable lands of sufficient extent in the natural direction of the drainage, have prevented the application of the sewage to the land becoming in any sense general. In 1875, the committee appointed by the Local Government Board to inquire into the various methods of sewage disposal reported "that land irrigation is not practicable in all cases." The object of this paper is to show that the adverse conditions which prevented the general adoption of this method of disposing of town sewage in England are for the most part absent in India. A trial extending over a quarter of a century has been made in Madras, where the local conditions are in no way exceptionally favorable, and has proved that an almost unlimited amount of sewage can be disposed of in this way in accordance with the best hygienic principles, and further that the produce of the farms finds a ready market and realizes a handsome profit on the outlay. At the same time I hope to give such practical details as will enable any one to make a more or less extended trial of the system with good prospects of success.

The idea of adopting land irrigation as the means of disposing of sewage in Madras was conceived by Mr. Standish Lee, the Municipal Engineer, in the year 1869. No worse site could have been found anywhere about Madras than that of the first experiment. This was in the neighbourhood of Chulay, and is now known as the D'Mellow's Road farm. It was a dismal swamp, periodically submerged by salt water, which on evaporation deposited a saline mud. The soil was black, plastic and as retentive as stiff clay. Not even a blade of grass grew there. Operations were commenced in June 1869. The swamp was reclaimed by depositing street sweepings and was planted with guinea grass. Some crops were obtained, but subsequently difficulties were encountered. With the advent of the hot weather of 1870 evaporation increased considerably, and salt was drawn to the surface forming a saline efflorescence if the ground was allowed to rest a few days. A large quantity of guinea grass perished, and some harriali, or dhoob, that had been planted, was not strong. A coarse swamp grass sprang up, which is known as cow grass (*Chloris barbata*), and is liked by cattle though unsuitable for horses. Moreover, the surface sank irregularly, throwing out the grading of the beds and necessitating a large amount of manual labour. Later on an inspection was made by an agricultural expert, who traced the main cause of the want of success to the sub-soil water, which was found in some parts of the farm at from four inches to two feet from the surface. The worst parts of the farm were under-drained at intervals of six feet with pipes running four feet from the surface, which was raised by the deposit of rubbish, and after this no further difficulty was experienced. My own opinion is that the drain pipes in this case were of little or no use, as they were placed below the level of the sub-soil water and had no outlet. The whole neighbourhood is low and swampy and at the present time water is found at from eighteen inches to two feet from the surface.

The next experiment was made in 1870 at Krishnampett near the sea-shore. Half the land taken up consisted of pure sea-sand, the remainder of land which had been reclaimed with rubbish and covered with a thin stratum of sand. Here no difficulty was encountered, the soil being porous and permitting the great desideratum of sewage farming—free downward percolation. Heavy crops were soon raised amounting in 1871–72 to about 69 tons of grass per acre. Since then a number of farms have been started, the principal one being known as the Black Town farm. This is admirably situated on the beach 2½ miles north of the town. It is so close to the shore that last year a considerable portion of it was carried away by a heavy

sea. The farms now in use and the areas they drain are shown in dark and light colors on the accompanying map. It will be noticed that some of them are in inhabited areas and are of comparatively small size. This is due to the want of any general system of drainage in the town. In my opinion the fundamental principle for any system of sewerage for Madras should be to carry all the sewage to the north and dispose of it on one large farm, which could be made by the extension of the present Black Town farm. This would be more economical and in other ways preferable to having a number of small farms scattered over the town.

Successful sewage-farming is to a considerable extent dependent on physical conditions. The geology and surface of Madras are thus described in a recent report by Mr. Edward Cousins, C.E.:—"The surface and sub-soil consists, as a rule, of deposits of white and grey sand in which occur at irregular intervals thin beds of clay. Water is found below the surface at varying depths but generally in the low-lying parts of the districts it corresponds with the mean level of the sea. At no part of this sandy plain are there any considerable elevations of the surface, the maximum heights are from 20 to 24 feet above mean sea level, while many portions of the town are only two feet to six feet above that level. The average elevation of the surface may be taken at about nine or ten feet." The higher parts of the town, being principally occupied by private houses with large compounds, have no drainage system, provision only being made for storm water. The parts providing sewage to be disposed of are all if anything below the average height given, which necessitates the lifting of the sewage by pumps, either from central pumping stations or from wells on the farms, which is a costly undertaking. At first only the water-lift of the country was used. This is known as the 'picottah' and consists of a lever balanced on a strong upright and worked up and down by men stepping from one side of the fulcrum to the other. But for any kind of manual pumping to be successful constant supervision is required, and now for the principal farms this primitive system has been superseded by the steam-pump, which is in every way more satisfactory. Gwynne centrifugal pumps have been found to answer best. The Ráyapuram pumping station, from which the sewage of Black Town is pumped to the Black Town farm, is fitted with three of them, each fifteen inches in diameter. The sewage is lifted from a well, into which three sewers empty their contents, and discharged into a cast-iron main 24 inches in diameter and about a mile and a third in length, being carried the remainder of the distance of 2½ miles in an open masonry channel. No further lifting is required after the sewage reaches the farm. Pumping at this station is carried on on an average 22½ hours daily, the amount of sewage pumped being about three million gallons. Night-soil is removed on the pail system and is not supposed to enter the drains, though the urine and washings of the latrines do so. The annual rainfall varies considerably, the average being about fifty inches, which is above the general average for India. A very large proportion of it falls between the middle of October and the middle of December.

As I consider the Black Town farm to be a fair model for an Indian sewage farm, I shall describe it somewhat in detail. The general arrangement is shown in the accompanying plan. The sewage passes from the outfall channel through culverts with sluices into the main carriers. These are banks of earth with a channel scooped out on the top. They run in parallel lines about 432 feet apart, giving off at right angles the secondary or distributing carriers, which are similar but somewhat smaller. The interval between the distributing carriers is 114 feet, and it is divided into two by a small bund, which runs through the beds half-way between them. This may be called the central bund. The beds slope down to it from the distributing carriers. It is absent in some of the farms, but I think it is a good thing to have it, as the grass may rot at the lowest part of the slope through the water standing there longest. It percolates through the bund, and so this is avoided. There are further bunds at intervals of six to eight feet running from near the distributing carriers down to the central bund. These are small and not more than four to six inches in height. They conduce to the equal distribution of the sewage over the grass. The junction of a distributing carrier with a main is made with a stoneware drain pipe of about six inches diameter. Grass grows freely over the bunds and over the carriers to the very edge of the channels, which become coated with a black sludge, which

hinders the sewage from sinking in though it allows enough percolation to keep the grass growing freely over them. Large drain tiles have been laid in some of the carriers, but they soon get displaced and serve no good purpose. The gradient of the carriers should be sufficient to ensure a fairly rapid flow without causing a scour. Where the amount of sewage to be disposed of is small, the beds should be made somewhat smaller than the measurements I have given, in order to get even distribution. The slope from the distributing carrier to the central bund is about 1 in 30.

The system of irrigation which has been found to answer best is to flood the beds heavily every three or four days, though it can be done oftener without any ill-effect. The method employed is to open the sluice in the outfall channel and let the sewage run into a main carrier. The drain pipes leading to the distributors to be used are left open; those which are not to be used are closed with earth and grass. If only the first part of a main carrier is required it can be bunded across at the required distance with earth. The same can be done with a distributor, which is then breached behind the barrier, and the sewage pours out and runs down the space between the distributor and the ends of the bunds that divide up the beds, and turns off between these bunds to run down the beds to the central bund. The men in charge of the farms say that they put on about four inches at a time, but the amount must be much larger as a good deal of sewage sinks in before it begins to lie on the surface. This method of intermittent irrigation economises the labour on a large farm, as only a third or a quarter of it has to be attended to every day. It also gives plenty of time for air to be drawn into the interstices of the soil and provide the oxygen which is necessary both for nitrification and the formation of tissue. Most cultivators irrigate equally all the time a crop is growing, but one of great experience told me that the younger the grass the more sewage it would take. The grass should not be irrigated for two or three days before it is cut. This allows it to harden, and though it does not weigh quite so much its quality is better and it does not wither so quickly. After the grass is cut, which is done in Madras with a sickle with a saw edge, the teeth being set the contrary way to an English saw, the ground should lie fallow for the best part of a week. The careful farmer will then take the opportunity of forking it and loosening the roots, though in some farms this is not done more than once a year. It favours the development of young roots to replace the old ones, and so preserves a healthy and vigorous growth. The beds should also be weeded. If this is done regularly it entails very little labour, but if it is neglected there may be some difficulty experienced. The grass is generally cut rather before it reaches maturity. The contractor reckons to cut a crop every 45 days, which gives eight crops a year. In the Municipal parks, where sewage irrigation is carried on, we do not get quite so many. The method of irrigation by blocking the channels with earth and breaching them is primitive, but it suits the native cultivator, who is very skilful with it, and it has been found to answer the purpose, so no attempt has been made to supersede it and introduce iron or wooden stoppers.

Some of the three million gallons of sewage daily pumped at the Ráyapuram station is drawn off to irrigate the Robinson Park, the remainder goes to the Black Town farms. Adding together the area of the park, the farm, and of certain private lands adjoining the farm which are irrigated by the contractor, we get a total of forty acres approximately. This gives a daily average of 75,000 gallons per acre. The experience of the Berlin farms is that not more than 2,000 to 3,000 gallons of daily sewage should be allotted per acre, so that the land may have the necessary periods of rest. At the Bedford farm in England about 5,200 gallons per acre are pumped daily and at the Beddington farm about 6,600 gallons, which is the largest amount I know of outside Madras. Yet the Madras contractor, who is getting twelve times as much sewage per acre as any European farm would stand, recently petitioned to have sewage irrigation stopped in the Robinson Park on the ground that he was not getting enough. This is a remarkable testimony to the porosity of the soil and the copious evaporation and transpiration that take place under the influence of the Indian sun. At times when I have visited the farm, especially after heavy rain, all the sewage was not being used, the surplus running into the sea at a point beyond the farm. The sewage which is used to irrigate the farm does not form a definite effluent,

but on careful examination I have found tiny rivulets trickling down from near the bottom of the wall of sand in which the farm ends where it drops down to join the sea-shore. The amount is so small that it was a long time before I noticed it.

As regards the crops that do best, though it has been found that nearly everything will grow under sewage irrigation, later experience has confirmed the verdict of the early experimenters in Madras, that harriali grass (*Cynodon Dactylon*, Hind.: Dhoob) is by far the most satisfactory. It has the advantage of being indigenous, for English and French experience has shown that the peculiar crop, whatever it may be, that suits the neighbourhood, seems to flourish under sewage. It is, moreover, a voracious feeder, and is not easily killed by excess of sewage. In the wild state in places where there is not much moisture it creeps for the most part below the surface of the ground. Native ponies may be seen scraping the surface of the ground with their hoofs and blowing away the dust to get at it, and will graze where there is not a blade of green grass to be seen. But, when abundantly irrigated it shoots up to a height of two feet or more and yields most luxuriant crops. Captain Horace Hayes, F.R.C.V.S., says of it in his book on "Horse Management in India": "In good soil when cultivated it loses its creeping character and grows like English meadow grass, to which I think it is much superior." A good farm yields about 45 tons of green grass per acre, which dries down to about 15 tons of hay. This compares very favourably with the Berlin farms, which yield 25 tons of grass or 5 tons of hay. From this it would appear that the grass grown in Madras contains less water than that grown in Germany. The English sewage farms yield about the same amount of hay as the German ones. This is about double the yield from English meadow land. So where we get one ton of hay from meadow land, we get two tons from European sewage farms and six tons from Madras sewage farms. This enormous difference may partly be attributed to the season of growth being continuous in India, whereas in Europe it is limited to the summer months, and partly to the fact that a high temperature in a soil or water up to 99° Fahrenheit increases the activity of nitrification and consequently of vegetable growth. The hay from the Madras farms is mostly sold to the Commissariat at Rs. 45 a ton. This gives an average money yield of Rs. 675, or about £37 sterling per acre, taking Rs. 18 to the pound, against £18 per acre, which is reported to be the average price of Italian rye grass grown on the Bedford sewage farm. When the differences in the cost of land and labour in the two countries are taken into account, it is easily seen how it comes to pass that sewage farming is so much more profitable in India than in England, for we have double the produce on probably less than a quarter the outlay. Besides the supply of hay to the Commissariat there is a fair market for grass and hay among horse-owners in the city, especially during the hot weather when grass is scarce.

With regard to the quality of our sewage-farm hay as forage, I wrote to Veterinary Major W. Gladstone, A.V.D., the officer in charge of the horses of His Excellency the Governor's Body Guard and the Royal Artillery at Saint Thomas' Mount, who replied:—

"Since hay from the sewage farms has been used at the Mount there has not been a single case of anthrax until this year, when on inquiry I found that one of the Majors was using grass-cutters' grass. This was stopped and since then we have not had a case. The same in the Body Guard. I strongly recommend hay from the sewage farms, as diseased cattle are not allowed to stray over the land, and it is by far the best forage you can get in Madras. Veterinary Colonel I. S. Shaw says that wherever dry hay has been used anthrax has not been known, and certainly I have not seen a case. In Belgaum in 1878 we had anthrax, and as soon as the grass-cutters were discharged it ceased and has not recurred since. The same in Bangalore, except when they are compelled to use green grass, as in camps of exercise, &c. So I believe the drying process and keeping diseased cattle off the land has a great deal to do with this immunity."

Other Veterinary Surgeons with whom I have discussed the matter have spoken equally in favour of sewage-farm hay.

Harriali grass grows better from roots than from seed. The roots should be planted in rows about six inches apart. It spreads quickly and in about two months a light crop can be cut. If it is planted in a soil recently made by the deposit of rubbish

the irrigation should be somewhat excessive; daily will not be too often. Otherwise the heat due to fermentation may kill the grass. It is advisable to let rubbish rest for six months or more before planting it, otherwise the level of the beds may be thrown out through its sinking irregularly. After planting, if the beds keep their level, there is nothing further to be done beyond weeding and forking. Beds, both of sand and of made soil, planted more than 20 years ago, are still yielding good crops, though, so far as I know, they have never been ploughed up or replanted. If a bed sinks in any part, a few cart-loads of rubbish will restore the level. If caterpillars appear, as they occasionally do about the end of the rainy season, a little freshly slaked lime will quickly put an end to them, failing which ashes are as good as anything.

About 50 acres of land are leased to a contractor. The amount was larger, but two farms have been abolished as the sewage supplied to them was carried to the Black Town farm after the opening of No. 2 sewer, and a considerable portion of the Black Town farm was carried away last year by the sea. Eleven acres more are being acquired, to be added to the Black Town farm. The contractor also irrigates about 20 acres of private land, part of which he leases from the owners and part he holds under an agreement with the Commissariat. The land in three public parks which is worked departmentally brings the total area up to about 100 acres.

Complaints of nuisance have been made against some of the Madras farms as against most sewage farms in other places. There is an ammoniacal smell from the sewage wells and main carriers at times, but apart from this the air over the farms themselves seems perfectly fresh and wholesome. No one with his eyes bandaged could perceive by the sense of smell that he was walking over a sewage farm. With regard to the sanitary aspect of the question there have always been differences of opinion. The Sanitary Commissioner for Madras appears to have a bad opinion of the Madras farms. For in his annual report for 1893, page 115, he writes: "Madras town pursues the system profitably but on bad sanitary principles; the sites being often within inhabited areas, no arrangement being made for underdraining and discharge of the effluent and in certain cases disposal by soakage in the neighbourhood or discharge into the Cooum being allowed during intermitting working of the pumping machinery." For my own part I think the Black Town and Kristnampet farms would compare favorably with farms in any part of the world. I cannot understand on what ground a charge of bad sanitary principle can be preferred against them. With regard to some of the farms being within inhabited areas, I have not found that the health of the people living near them is worse than elsewhere. Taking cholera as a disease specially prone to appear under insanitary conditions, spot maps showing the mortality do not indicate that the disease has shown a special preference for the neighbourhood of the farms. There is nothing to show that diarrhœa, dysentery, typhoid, or diphtheria specially affect these localities. Dr. Alfred Carpenter, who has had a practical experience of 30 years or more and made a special study of the question in connection with the English farms, lays it down as a proposition "that the judicious application of sewage in close proximity to dwelling-houses does not depreciate the health of the inhabitants." "In no single instance," he said on one occasion, "out of nearly 100 cases in which sewage has been utilized by broad irrigation has any fact been proved to establish the allegations of 'insanitariness' which are sometimes brought against them." There is a Female Orphan Asylum with 200 inmates on the border of the Croydon farm and the health of the children is said to be unaffected. Many Lunatic Asylums utilize their sewage on their own grounds with excellent results. The General Hospital, Madras, has diverted its sewage from the river Cooum and employs it to irrigate a strip of land close to some of the buildings. The result is a vast improvement to the appearance of the place, and I have not heard that any complaints have been received from the Medical or Surgical staff that the health of their patients has been injuriously affected. I think they give Surgeon-Colonel Price considerable credit for the innovation. It will be seen from the map that most of the farms within inhabited areas are small. Most of them are irrigated only by means of picottahs, which limits the supply, and I believe that in India unless the supply is very abundant very little, if any, water reaches the sub-soil water. These farms will doubtless be abolished and the Black Town farm

extended when a comprehensive system of sewerage is introduced. For the present I believe they serve a useful purpose in utilizing sewage that would otherwise be discharged into the river or canals or soak into and pollute the ground. With regard to under-drainage, its objects are to prevent the soil from becoming water-logged, which ruins the crops and prevents the proper exercise of its purifying action on sewage, and to enable a larger quantity of liquid to be disposed of. It has never been successfully employed in Indian agricultural operations. In a trial made at the Saidapet experimental farm it was found that its efficiency was destroyed through the pipes getting blocked by white ants, &c. It is quite unnecessary in a highly permeable soil that permits free percolation. In the Berlin farms it was not adopted at first, but was subsequently resorted to when the soil got water-logged, 2-inch pipes being laid 16 to 33 feet apart at an average depth of three to four feet. In most of the Madras farms there is no water to be found under five or six feet and I have dug down to a depth of ten feet close to where irrigation was being carried on without getting any accumulation. There is no impervious stratum under them for a considerable distance down, D'Mellow's road being an exception, as it has an impervious stratum and is only slightly raised above the surrounding swamp. In England and Germany it is found that less than half the sewage used for irrigation flows away as an effluent. In India the proportion must be very much less, as evaporation and transpiration are enormously increased under the influence of the tropical heat.*

This enables us to use large volumes of sewage for irrigation without underdraining and without appreciably raising the level of the sub-soil water. I know of an instance in which a small sewage farm was started which was irrigated daily. A well within a few yards of the farm, which was used for irrigating a plot of grass, had to be deepened to get water enough for the purpose, which would not have been necessary if the sub-soil water level had been raised by the percolation of sewage through the ground exceeding the amount given off by evaporation and transpiration. In India, if the sewage to be disposed of is too much for the land, it is better, where it is possible, to extend the farms, rather than to increase the effluent by underdrainage. The drains leading to the Napier Park and People's Park have over-flows into the Cooum, by which sewage enters the river at night, when the pumps are at rest, or during heavy rains. So have the drains leading to two small picottah farms, Pudupet and Dam's road. It is proposed to introduce storage tanks to intercept the sewage that now escapes into the river, which is inconsiderable in amount. I do not know what is referred to by disposal by soakage. In some parts of the town there is soakage, but this is due to the want of proper drains and not to sewage-farming on bad sanitary principles. Sewage-farming can only be held responsible for the disposal of sewage when it reaches its destination and not for defects in the sewerage and drainage of a town.

The price paid for land for sewage-farming in Madras has not been high, and from what I have seen of other Indian towns, I believe that cheap land suitable for the purpose would generally be procurable. In the Madras farms there are practically only two types of soil—sand and made soil. They are both porous in a high degree and to about an equal extent. To test their porosity and their purifying action on sewage I recently performed some simple experiments. I had four filters or guages

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* Some idea of this can be got from the following extract from a paper by Messrs. Dawes, Gilbert and Warrington in the Journal of the Royal Agricultural Society of England, 1881:—

"As the transpiration of water in a plant is determined by light, the amount of transpiration must have some connection with the rate of assimilation and growth. When the supply of water and of soluble plant food is tolerably constant, the relation between transpiration and growth will be fairly regular. From experiments made at Rothamstead many years ago with plants grown in pots it was concluded that from 250 to 300 lb. of water were evaporated for 1 lb. of dry matter added to a plant. It may be, however, that in a soil poor in soluble plant food a larger amount would pass through the crop to yield the same amount of assimilation than in a soil well manured. The relation between transpiration and assimilation will indeed probably differ under different circumstances."

The soil in the Black Town farm containing practically no soluble plant food, the amount of water transpired might be expected to be large. Taking into account the intense brightness of the sun light it would probably be within the mark to estimate it at double the amount given above. An acre yields 15 tons of dry matter. This would give 15 × 600 tons of water transpired.

9,000 tons = 20,160,000 lb., or 2,016,000 gallons per annum = $\frac{2,016,000}{365}$ gallons a day = 5,523 gallons a day.

The amount lost by evaporation in India which averages 0·22 of an inch should be added to this. This is 49,280 gallons an acre and is probably more than actually evaporates, as water is not always standing on the beds. On this reckoning transpiration and evaporation together would daily amount to 54,803 gallons per acre, or more than two-thirds of the sewage water allowed for irrigation. 21,197 gallons would be left to join the sub-soil water. The amount lost by transpiration is probably more than the estimate taken.

made, each consisting of three 9-inch drain pipes joined together and cemented so as to form impervious cylinders rather more than six feet in length. These were placed perpendicularly on wooden stands with perforated iron plates intervening and galvanized iron buckets placed underneath. Two of these I filled with earth from the Robinson Park and the other two with sand from the Black Town farm, first putting a few pebbles and pieces of broken pot at the bottom. On the top I put grass from the farms, partly as I believed it would act as a strainer, partly in order to obtain any action the roots might have upon the sewage as it passed over them, and generally to reproduce as nearly as possible the natural conditions of a farm. The soil of the Robinson Park was originally street sweepings; it is now a rich and friable loam of a dark brown colour. The soil of the Black Town farm was originally sea-sand, and as far as its physical characters are concerned it has practically undergone no alteration though subjected to sewage irrigation for over a decade. I put sewage in at the top and caught the effluent water in the buckets at the bottom. The time taken by the sewage to pass through varied somewhat, its first appearance being in two to three hours when the soil was comparatively dry and half to one hour when it was fairly moist at the time of starting the experiment. It passed through the made soil quite as quickly as through the sand, which was contrary to expectation. I began by putting two gallons of sewage, pint by pint, into each filter. About half of it was absorbed by the soil almost immediately, the remainder stood on the surface and percolated down much more gradually. As soon as it began to come through the first filter I added a gallon more to each in order to get enough effluent for analysis. I sent samples of the sewage used, which was taken from the well in the Ráyapuram pumping station, and of the effluents, to Surgeon-Major J. L. VanGeyzel, M.B., F.C.S., &c., Chemical Examiner to Government, who very kindly analysed them for me. The following are the results of his analysis:—

Analysis.

Parts per 100,000.

—	Suspended solids.			Dissolved solids.			Chlorine.	Free ammonia.	Albumenoid ammonia.	Nitric acid.
	Organic.	Inorganic.	Total.	Organic.	Inorganic.	Total.				
Filtered effluent sandy soil from Black Town Sewage Farm	0·100	1·600	1·700	205·000	555·000	760·000	269·800	0·120	0·220	8·670
Sewage from Ráyapuram Pumping Station ..	12·700	19·700	32·400	66·000	299·000	365·000	170·400	5·200	0·560	0·210
Filtered effluent (No. 1 Filter) made soil from Robinson Park Sewage Farm	Trace.	0·200	0·200	117·000	304·000	421·000	138·400	0 024	0·056	16·920
Filtered effluent (No. 2 Filter) made soil from Robinson Park Sewage Farm	Trace.	0·400	0·400	105·000	280·000	385·000	120·700	0·019	0 064	16·500

The character or source of the organic matter cannot well be inferred from the above analysis in the absence of determinations of the amount of organic carbon and nitrogen present. Owing to the short space of time unavoidably allowed to the analyst, these determinations had to be omitted. The filtration performed in the experiments was necessarily imperfect. The soil in the filters was much less compact than that in the farms, where it had been rained upon and irrigated for years. If I had had the means available of isolating sections of the farms without disturbing the soil and had been able to utilize a larger area in proportion to the sewage used, I believe that the effluents obtained would have been purer. The sewage put on—2 gallons to an area of 63·6 square inches—is equivalent to 591,750 gallons an acre, which is seven times as much as the average daily amount used on the Black Town farm, or more than twice the amount used at a flooding done every three days. The sample

of sewage analysed contained rather less suspended matters and free ammonia, much less combined ammonia and much more matters in solution and chlorine than are contained in English sewage of average composition. At the same time, the results obtained amply demonstrate the purifying powers of the soil and are in the main in accordance with the results of English experiments. The effluent water was clear, odourless and practically colourless. The analyses show that it contains less suspended organic impurities and much less free and albumenoid ammonia than the sub-soil water in parts of Black Town of which I have analyses. It would so far pass the standards of purity adopted by the Commissioners appointed to inquire into the best means of preventing the pollution of rivers. The most noteworthy point, whether from the point of view of the sanitarian or of the agriculturist, is the retention by the soil of the suspended organic matter and ammonia in solution and the appearance in the effluent of nitrates. According to modern theories based on the experiments of M. M. Schlæsing and Muntz and Messrs. Lawes, Gilbert and Warrington, this is due to nitrification brought about by the presence of living organisms, which specially occupy the first 18 inches of the top soil. The vital activity of these living ferments varies with the temperature, being very low near freezing point and reaching its maximum at 99° Fahr. I have not got reliable records of soil temperatures in Madras, but a few days ago (early in November) I took some temperatures of the soil on the Black Town farm in the early morning, which were over 80° Fahr., so that that it is probably between 80° and 100° Fahr. generally, which is the most favorable temperature for the process, and so in the highest degree conducive to the purification of sewage. In a paper read before the Society of Arts in 1882, Mr. Warrington pointed out that "a filtering medium of pure sand and limestone, treated intermittently with sewage, will after a time display considerable purifying powers, the surfaces becoming covered with oxydising organisms derived from the sewage. No such medium will, however, equal in effect a porous soil rich in organic life." This explains what might seem strange in the results of the analysis, that the effluent from the made soil contains much less unoxydised nitrogen than that from the sand. The experiments of the Rivers Pollution Commissioners with soils from different farms appear to show that the cleansing power of a soil is more closely connected with physical conditions as regards porosity and fineness of division than with its chemical composition; and of two soils not differing very widely in chemical composition, namely Hambrook and Dursley, one (the latter) was found to have twice the purifying power of the other. Judging from my experiments it would appear that made soil, which is the finer and richer of the two, had a greater purifying power than sand, and, as the porosity is about equal, though both are admirably suited for sewage-farming, where both were available made soil should be taken by preference, or sand might be covered with sweepings to a height of one or two feet to give it a more active nitrifying surface stratum. Presumably the nitrates in the effluent were in the soil when it was taken from the farm and were the result of former nitrification and not produced from the organic matter and ammonia in the sewage used in the experiments. The large amount of chlorides is probably due partly to the urine contained in the sewage and partly to the proximity of the sea. The amount in the effluent from the Black Town farm soil, which was taken from a spot about 200 yards from the sea-shore, was more than double that of the Robinson Park, which is more than half-a-mile from the sea. These experiments, imperfect as they were, and the analysis made by Dr. VanGeyzel, convince me that what little effluent percolates through our farms may safely be allowed to join the sub-soil water without any fear of polluting it or in any way endangering the public health. I have already shown good reason for believing that there is not very much of it, that the water-level is not appreciably raised, and that the crops are healthy and vigorous. Hence, so far as I can see, no reason exists for underdrainage, which would, moreover, entail great difficulties and expense; for the ground is in many of the farms so level that the effluent would not run off, so that it would have to be pumped, and there would be nowhere for it to go to unless it were thrown on to the beds again and so be sent round and round in a vicious circle.

Under the arrangement with the sewage-farm contractor the Municipal Commissioners undertake to pay the rent, establishment and labour. The contractor must keep in repair the sewers, drains, cisterns, channel-pipes and other things connected with

the delivery of sewage in or on the farms. He must dispose of as much sewage on th land as the Commissioners deliver. He must cultivate and manage the farms in the most approved manner and keep them in a clean condition, free from weeds, &c. He must allow free access to the farms to the officers and servants of the Municipality, in order that they may see in what state the farms are kept and whether any part is in need of repair, &c.; if so, to give notice to the lessee, who must execute the repairs within fifteen days. The contractor has the right of constructing new wells, cisterns, &c., if he first obtains consent for the proposed work. The Commissioners agree not to stop the delivery of sewage at any one time for a longer period than five days. The contractor is allowed to cultivate or irrigate with sewage other land than municipal land with the consent of the President, and pays to the Commissioners Rs. 250 per cawnie (1 cawnie = 1·322 acres) per annum for lands so cultivated. The contractor has to cultivate and irrigate any other land acquired, rented or handed over to the Municipality, and pays the Commissioners Rs. 300 per cawnie per annum for lands so cultivated. The contractor makes a deposit of a Government of India promissory note for Rs. 4,750 as security. Deductions may be made from this in the event of a breach of contract.

The contract system which was introduced in 1888 has been found to be more profitable than working the farms departmentally. The usual objection to it is that a contractor has an eye only to profit and will not use all the sewage on the farms for fear of injuring his crops. No trouble has been experienced from this cause in Madras, partly through the voracity of harriali and partly through the well-known prodigality of the Indian cultivator in the matter of irrigation. One contractor allowed weeds and objectionable kinds of grass to gain ground, especially a kind of swamp grass with strong interlacing roots (*Panicum fluitans*) which gained a hold in the D'Mellow's Road farm, and to a less extent cow grass (*Chloris barbata*).

The farms are put up to public auction triennially. At the first sale in 1888 Rs. 7,250 per annum, or Rs. 21,750 for the whole period, was the highest bid. On this, if the cost of pumping on the farms be included, there was a loss on the three years as shown below :—

Income.	RS.	A.	P.	*Expenditure.*	RS.	A.	P.
Rent of farms	21,750	0	0	Establishment	1,920	1	9
				Overtime	153	10	8
				Fitters staff	721	1	3
				Labour (including pumping) ..	35,414	5	10
Loss	19,239	11	6	Rent of sewage farms ..	2,780	8	6
	40,989	11	6		40,989	11	6

This shows a loss of Rs. 19,239–11–6, or rather more than Rs. 6,000 a year. In 1891 the better price of Rs. 15,600 per annum, or Rs. 46,800 for the three years, was obtained. On this an actual profit of Rs. 18,307 was realised, the expenditure having been somewhat reduced. In 1894 the farms were let for Rs. 19,000 per annum or Rs. 57,000 for the three years. The following is an estimate of the income and expenditure for the period :—

Income.	RS.	*Expenditure.*	RS.
Rent of farms	57,000	Rent, maintenance, &c.	30,630
Private land	14,850		
Added land (2½ years)	5,312	Profit	46,532
Total ..	77,162	Total ..	77,162

The estimated profit for the period is thus seen to amount to Rs. 46,532.

The conclusions I draw from the evidence adduced are as follows :—

(1) Barren land can be acquired at a moderate cost in the vicinity of most Indian towns.

(2) No matter how barren the land is, if it is permeable, it can be utilized for the formation of sewage farms.

(3) Sewage farms in India can be laid out at small cost, a maistry with a gang of coolies being able to do the grading of the beds and make the bunds and channels.

(4) Owing to growth being continuous more crops can be raised in India than in Europe and sewage can be more satisfactorily disposed of in very large quantities throughout the year.

(5) Owing to the temperature of the soil being particularly favorable to nitrification and growth in the presence of sufficient water the crops are very heavy.

(6) Owing to the scarcity of good forage during a great part of the year there is usually a good market for grass and hay.

(7) Owing to the exclusion of diseased cattle from the farms the grass is not liable to infection with disease germs. The hay compares favorably as a food stuff with forage from other sources.

(8) Sewage-farming can be carried on in the proximity of houses without affecting the health of the residents, though it is better to locate the farms at a distance from a town as there may be some nuisance from the sewage wells and main carriers owing to the decomposition of the sewage before it reaches the farms.

(9) Owing to porosity of the ground and the enormous volumes of water given off by evaporation and transpiration, under-draining is not generally necessary though it may be in particular cases.

(10) Sewage after passing through the ground is sufficiently purified to be admitted into a river, or to join the sub-soil water without causing pollution

(11) The native cultivator is quite capable of laying out farms and carrying on sewage cultivation without close European supervision. He is an adept at irrigation processes, having inherited his aptitude and familiarized himself with the methods almost from the time of his birth.

(12) The system is suitable to parts of India where the ground is permeable and the rainfall is not excessive. It can be carried on profitably even where the flatness of the land necessitates the use of pumps, and should yield a much higher profit where the natural slope of the land permits them to be dispensed with.

No. 25.

Referred to the Sanitary Board for remarks.

(By order.)

FORT ST. GEORGE,
12*th January* 1894.

(Signed) W. FRANCIS,
Acting Assistant Secretary.

To the Sanitary Board.

From Surgeon-Lieutenant-Colonel W. G. KING, M.B., C.M., D.P.H., Acting Sanitary Commissioner for Madras, Secretary (General Sanitation Department), Sanitary Board, to the Chief Secretary to Government, dated Camp, Tirupati, 10th March 1895, No. 472–S.

With reference to G.O., dated 12th January 1895, No. 25, Local and Municipal, I have the honour to forward herewith my remarks on Dr. Nield Cook's paper on sewage farming in Madras.

Remarks by the Acting Sanitary Commissioner for Madras as to Madras Sewage Farming.

Most of the matters dealt with in Dr. Cook's Medical Congress paper have been long established, and I therefore would confine attention to such unusual conclusions as I think require modification. Dr. Cook states, "owing to the exclusion from the farm of diseased cattle, the grass *is not liable* [italics mine] to infection with disease germs." Because a place is styled a sewage farm and even cattle be excluded, it does

not follow that infection will not occur. This is solely a question as to what chances the sewage used had of infection and of getting rid of it before arrival at the farm. The instance given in support of this contention at page 5 of Dr. Cook's paper, simply points to the possibility of well-dried hay being a safer forage where anthrax is concerned than grass, the reason being that prolonged exposure to sunlight is inimical to anthrax spores, whilst damp grass and ill-drained soil offer conditions favourable to their vitality. Against this, however, must be placed the experience that hay by its mechanical action is by good authorities held to be likely to favour infection by the making of abrasions in the mouths of animals. In the case of a sewage farm devoid of under-drainage and subject to waterlogging as in the case of DeMellow's, anthrax spores introduced with the sewage would be in little better position than in the damp soil surrounding many of our villages. But there is this to be said; in town life anthrax blood ought very rarely to reach the drains, the animal being usually taken out entire from the neighbourhood of habitations; whereas, in the country, the cutting up of animals is practised by chucklers where the animal drops, and by this process the spores, as contrasted with the bacilli, are set free. Of course, I do not forget the claims of certain authorities that pathogenic microbic life suffers in sewage farms as a result of crowding out by saprophytic germs and alkalinity of the sewage; but, on the other hand, I cannot so far forget the highly-resistant character of the anthrax spores, and the variable factors that have to be dealt with in connection with sewage farming, as not to consider Dr. Cook's assumption that sewage farms are "not liable" to infection as dogmatic, and likely to lead to serious neglect of requisite precautions.

Again, he affirms that "sewage farming can be carried on in the proximity of houses without affecting the health of the residents, though it is better to locate the farms at a distance from the town as there may be some nuisance from the sewage wells and main carriers owing to decomposition of the sewage before it reaches the farms." To assign as the sole reason for removing sewage farms from inhabited areas that "some" nuisance may result from the main carriers is to say the least regarding a serious sanitary question lightly.

Dr. Cook quotes, as supporting his contention as to innocuousness, Dr. Carpenter's conclusions as to the Croydon farm. That enthusiast would have had us believe that either the grass seized disease germs, or that they committed suicide by entering into the grass! But here is what the Medical officer (Dr. Creasy) of the Orphan Asylum, mentioned by Dr. Cook as being in the neighbourhood of the farm, reports on the subject—"typhoid fever has been in every cottage on the estate." The Medical officer of Health, Croydon, also some time back persisted, in spite of Dr. Carpenter's opinion, in regarding the presence of the farm as influencing the propagation of scarlet fever in the vicinity. Again, we have the classical instance of the Cumberland and Westmoreland Lunatic Asylum, where dysentery was traced to mismanagement of the sewage farm. Pasteur's recent protest against sewage farming in the vicinity of Paris also cannot be ignored. The evidence produced by Dr. Cook as to the innocuousness of the Madras sewage farms is unfortunately of little utility. Such a matter cannot be approached without correctly-worked out statistics; loose statements can be of no value in deciding so important a question. That he might have difficulty in a town having a mortality of over 10 per mille in finding that the localities of sewage farms are specially affected with certain diseases I can well imagine, the condition of the sub-soil of Madras generally being that of a badly-managed sewage farm; but to deduce statements as to safety, applicable to India generally, from observations made in so insanitary an area as the Madras Municipality would demand a very close study of refinements in vital statistics.

His conclusion that, "owing to porosity of the ground and the enormous volumes of water given off by evaporation and transpiration, under-draining is not generally necessary, though it may be in particular cases," seems to me to exhibit confusion of ideas as to the functions expected of under-drainage. It stands to reason that the greater the rate of evaporation the quicker will porosity diminish simply from rapidity of deposit of sludge on the soil surface; porosity being diminished, the greater would be the urgency for under-drainage in reference to nitrification.

Another conclusion of Dr. Cook's is as follows:—"Sewage after passing through the ground is sufficiently purified to be admitted into a river, or to join the sub-soil water without causing pollution." This is a most dangerous generalization. Of investigations as to the influence of filtration of sewage through soil, there is endless evidence from the time of the Rivers Pollution Commission downwards. No more complete testimony can possibly be quoted than that obtained through a series of years, aided by all the resources of modern science, than the investigations of the Massachusetts Sanitary Board. Their chemical and biological examination of filtrates of sewage, under every conceivable condition, amount to many thousands. The utmost any expert on this subject has hitherto ventured to affirm, nevertheless, in view of this mass of evidence, is that as a result of filtration through soil there is secured one of the best practicable methods of purifying sewage; but no one has yet been found who would assert that in the filtrate joining either sub-soil or rivers "pollution"—in whatever sense that term open to most varied interpretation, is applied—does not occur, or, that its freedom from disease-bearing agents is so absolute as to warrant its being stated that it is incapable of "in any way endangering the public health."

That many important towns in civilized countries are obliged to get rid of their effluent into rivers is a matter of necessity, and is accomplished with the knowledge that dilution and the various processes of self-purification will further aid in the work of prevention of danger, already attempted by filtration through soil. The same reasoning applies to the admission of such filtrate to the subsoil water; no one would however deny that danger exists. Thus, on the Paris sewage farms, rather than run the risk of contamination of the sub-soil, it is ruled that when the effluent from the under-drains is interrupted by rise of the Seine, the crude sewage must be discharged into the river.

Dr. Cook has gone to the trouble of making three special experiments with soils from the local sewage farms. He shows that he produced a filtrate that was equalled in evil composition with that of certain waters in Black Town, and he argues therefrom that no untoward result will occur, by sewage that has passed through a sewage farm entering the sub-soil. This, of course, proves nothing; as no one would wish to affirm that the sewage sodden soil of Madras is likely to produce good water in other than unusual localities. But, to argue from such data to a general application elsewhere, is quite another matter. In the first place, in localities other than Madras such an effluent would seriously pollute the sub-soil considered merely from its chemical composition; but Dr. Cook's experiment ignores the factor upon which any evidence as to disease production must be based. Although a certain unwonted proportion of albumenoid ammonia and chlorine would certainly not improve a human being's chances against disease, the risk cannot be gauged by this, but by the presence or absence of the causative agents—that is, of specific microbes. On this important point Dr. Cook's results afford no information; the experiments of the Massachusetts Board, however, supply the deficiency. It is shown that sewage filters working under the most favourable conditions can deprive sewage passing through them of 99 per cent. of micro-organisms. But seeing that each cubic centimetre, or, say, each half-teaspoonful, may contain 1,000,000 microbes originally, the chances of specific disease germs reaching sub-soil water in the vicinity of a sewage farm can hardly be ignored; especially if this addition to the soil proceeds year after year, and there be no under-drainage to assist nitrification and to remove the effluent to the further self-purifying processes of water-courses and sunlight. But whilst this is the best result procurable, it must be remembered that 95 per cent. is in certain conditions found to be all that can be accomplished, and that errors of management reduce this enormously. When, therefore, Dr. Cook points to his three experiments as proving the safety of sub-soil water from pollution, his conclusions can hardly be said to be complete, irrespective of the circumstance that the factor of prolonged use of the filter has not been entered into. Moreover—probably unconsciously—he has in this experiment not faithfully imitated the processes which proceed on Madras sewage farms; his filter represented a farm *with* under-drainage, which he has decried as unnecessary.

His deductions from these experiments that "made soil" is rich in nitrifying organisms is universally acknowledged, but I cannot help thinking his advice to

imitate its efficacy by using *two feet* of "sweepings" over sand goes beyond solid facts. If there be a large amount of nitrifying microbes in such a mixture, so also have they a large amount of organic matter to get rid of without its being added to by sewage being forced upon it. In short, with two feet of ordinary Madras town sweepings above a layer of sand, the latter would find its work of purification pretty well cut out for it in disposing of the filth—including fœcal matter—brought from this source alone. Instead of thus trammelling biological action, experiments show that by permitting the entrance of oxygen within the soil voids by quickly depriving it of excess of moisture, air finds entrance and *thus nitrification can be best supported*—an effect that can be brought about by under-drainage. Dr. Cook's further inference that if he had possessed a filter with earth more compact * as in the case of soil of the farms that had been long used he would have secured better results chemically, is also not in accordance with actual testing of such comparative conditions nor with the theory of nitrification just alluded to.

When, however, applying experimental results to practice, it is hardly necessary for me to say that the sub-soil of towns does not always fulfil the condition of a neatly-constructed filter, such as depicted in Dr. Cook's diagram. There are few sub-soils that have not faults, varying levels, and crevices that would guide, or permit to pass, sewage before it has undergone purification. Thus, places distant from the point of deposit may by sub-soil soakage be contaminated with sewage, and every year that a patch of soil receives filth and is taxed to purify it, there is ample proof that the greater liability is there for sub-soil pollution. Once a pathogenic microbe has successfully run the gauntlet of the upper 18 inches of soil teeming with saprophytes, the chances of being carried forward with the sub-soil water, and being aided in multiplication by the presence of nitrates from the sewage filtrate, are favourable. The classical instance of the Lausen typhoid epidemic showed that by irrigation of the soil surface, the typhoid bacillus can be sent through *a mile of sub-soil*.

In consideration of the fact that sewage reaches the soil of Black Town from other sources, I by no means wish to lay the blame solely to sewage farming, or solely to the fearful mass of diluted sewage collected in the Versarpady tank—*vide* Photograph No. 11—that escapes treatment on farms between Pursewalkum and Cochrane's Canal, but it is indubitable that within the last few years the "Seven Wells" water has deteriorated in quality. Further, coincidently with a fall of the sub-soil water—though not proved necessarily to be depending on this cause—typhoid fever increased amongst British troops using it to a lamentable extent. These wells are in a line with the sub-soil water flow from the points of pollution named. Whether or not the troops obtained the specific disease of typhoid from these waters, the progressive defilement which the wells have undergone, as proved by chemical analysis, shows that allowing sewage to pass through earth, whether the site be called a sewage farm or a street, matters little, and that, as time advances, if the filter be overtaxed, pollution of the sub-soil water results. Indeed, I should think that the mere *possibility* of defective filtration through the surface soil permitting pathogenic germs to pass, should forbid sewage farms being placed in a position in which they could add *in any degree* to the impurities of the sub-soil of an inhabited area. I would point to the fact that if the Health Officer's spot-map of the epidemic of cholera of 1892 be examined, it will be found that there was decided preference for the disease to flourish in those parts of Black Town within the sub-soil flow of the insanitary areas I have alluded to. I noticed this tendency of the disease in my investigation of the epidemic of 1882 (*vide* my Report thereon) and regarded preference of the disease for the parts near the sea coast as due to the increasing increments of filth brought by the sub-soil flow thither proving an auxiliary cause of propagation in the presence of the cholera microbe.

In this connection, it is well to remember that certain of the Madras sewage farms are formed, as Dr. Nield Cook would advise, of town rubbish; that is to say, in the special case of Madras, of a very large amount of fœcal matter *plus* rubbish. This

* To prove that the process of purification did not depend upon the compactness of the pores though which sewage was passed, the Massachusetts Board used gravel stones of the size of beans, which were previously washed free of all sand. The Board concluded that "the removal of this organic matter is in no sense a mechanical one of holding back material between the stones, for they are as clean as they were a year ago; but it is a chemical change, aided by bacteria".—W.G.K.

process is shown in Photograph 9. In this instance, the dumping has been effected so as to build in the walls of native huts! Possibly, the Health Officer trusted to the powers of ten inches or so of mud wall between the coolies and this filth, to protect them from disease germs. But, granted public bodies made, as they should, their farms of clean material, if necessity compelled their use within the water-shed or sub-soil flow of inhabited areas, I need hardly point to the danger of their being informed that it is safe for a population depending on well-water to so risk its contamination. In this connection, it must be remembered that few of our towns are yet provided with public water-supply systems. To argue that in the absence of a correct sewerage system, disposal of sewage on farms within inhabited areas on sites as completely out of the direction of the sub-soil flow through the town as feasible is justifiable, is the utmost that can be said; but to attempt from faulty data at disposal in the town of Madras to teach the people of India that to retain sewage farms in the midst of inhabited areas is neither to risk health nor the purity of well water, is subversive of the ordinary principles of hygiene.

It would have rendered me more capable of understanding the "strong opinions" I am supposed to have "inferentially" stated, had the Health Officer taken the trouble to speak of sewage farms within inhabited areas and those without. To the former, my remarks as to absence of under-drainage are obviously applicable. As to proposing under-drainage at the time of writing, I had no such intention; I simply described the condition of these farms with reference to sanitary results on their surroundings as aggravated by there being no under-drains. When my Annual Report was written, I had every reason to hope that Government would adopt the recommendation of the Water-Supply and Drainage Committee of 1890 (of which I was a member), and would abolish all farms within inhabited areas—a recommendation Dr. Nield Cook would now seem to coincide with, although it seems to me a surprising position to be assumed in view of his declaration of their innocuousness. But, in view of the change of intention of Government as to carrying out Mr. Cousins' sewerage scheme, of which I have been since informed, the question of the advisability of correcting the evil conditions that have been allowed to exist on the farms in inhabited areas ought certainly to be considered. Where I think this action desirable, I will state further on.

Dr. Cook attempts to be-little the effects of under-drainage in a manner that ought to have no influence upon his readers. After stating that under-draining had been employed in a portion of the DeMellow's farm, he gives it as his opinion that "the drain pipes in this case were of little or no use, as they were placed below the level of the sub-soil water and had no outlet."

Now, it seems to me most unlikely that an engineer would have laid down sub-soil drains without an outlet, whilst, even if this were so, the drains would not have been without a certain amount of influence in facilitating air change and water subsidence. At any rate, here is Mr. Lee's statement of the results, which I extract from a very interesting report written on sewage farming in Madras by that officer in 1872: —

> "This gave the key to our action. That part of the farm where we could get absolutely nothing to grow was, on Mr. Robertson's recommendation, immediately broken up to a depth of 18 inches and drained every six feet with pipes four feet under the ground level. With marvellous rapidity we obtained an excellent crop of grass. This advance has been maintained, and these beds are now one of the most productive portions of the farm. The supply of pipes running short, many of the beds were drained less thoroughly by a layer of loose brickbats about six inches in depth placed at the bottom of the drain-cutting and then covered in. In others a thin earthen tile was placed at the bottom and the loose brickbats placed upon that. The closeness of the drains made up for their imperfection and that portion of the farm is now almost too well drained, since the sewage runs through so freely that a large flow is necessary to ensure that the lower end of the bed shall be irrigated. Such careful and thorough drainage is costly and requires much time. There has been

neither means nor opportunity for covering the whole farm with such a net-work, though it is hoped that in the course of time, the whole may be provided with drains fifteen feet apart and four feet deep."

Surely, the statements of the officers concerned at that time who saw the results, namely, Dr. Cornish, Mr. Lock and Mr. Standish Lee ought not to require to be balanced against the opinion given "inferentially" of the Health Officer of 26 years subsequently. Indeed, I am inclined to think that if the Health Officer searches for them, he will find the missing outlets.

As to the quantities which Dr. Cook says are disposed of on the Madras * farms, I think, unless he produces much better evidence than the statement that a contractor demanded more after receiving an amount twelve times greater than is required on ordinary farms, the estimate may well be open to doubt. Dr. Cook himself states that he has at times seen the sewage of the Black Town farm not being used, especially after heavy rain. It has been my fortune to see it also thus wasted, and I presume that at the Black Town farm, as in other farms of Madras, the contractors take care not to forget that their interest is the production of grass and that during certain stages of growth flooding is not desirable. That contractors should wish to deprive a rival of a supply of sewage is hardly a fact that can aid the conception of the amount really used. It is, in short, not enough that such and such an amount passes on to a farm; it is requisite that it be shown that a measured amount of sewage is taken up by a measured amount of land daily, from month to month and year to year, when worked on sewage farm principles, and that a correctly-purified effluent results.

In any case, the utility of teaching that soil should be taxed as to disposal is open to question. Experience everywhere shows that even in a sandy soil the capacity for filtering steadily diminishes as time advances, and hence the usual resort to under-drainage. The greater the amount of sewage per acre the less perfectly can purification be accomplished, and the greater the risk of sub-soil water contamination. But whether the soil used be of India or Great Britain, the sewage to be purified must bear a certain definite proportion to the voids in the soil, degree of concentration of sewage, and activity of nitrification. In the latter process only, therefore, is there likely to be any advantage in India that is not reaped elsewhere, in view of favorable temperature. But in making any estimate for general application, it must be held in mind that Madras sewage is not likely to be representative of that in towns where correct methods of removal are in force. Here, sewage passes in open drains of small velocity permitting of deposit at every interruption of a leaf or stone, and thus sludge, which should reach the farm with the water, is removed by hand into carts in the streets; and it must be understood that it is the disposal of this sludge on the soil that chiefly taxes its capacity. But, granting Dr. Cook's data give a correct standard for India, it stands to reason that by employing under-drainage even a greater amounts could be disposed of, and that nitrification would be proportionately invigorated by air admission. †

In short, Dr. Cook has, in my opinion, deduced no trustworthy evidence to show why the general principles holding good for Europe and America should not apply to India also.

Having thus discussed those parts of Dr. Cook's conclusions that are not in accordance with usually-accepted data, I would proceed to the points at issue as to the present management of the Madras sewage farms. In the first place, certain admissions made by Dr. Cook must be given attention to; speaking of the Black Town farm, he says, (1) "at times when I had visited this farm, especially after heavy rain, all the sewage was not being used, the surplus running into the sea at a point beyond the farm." [It will be noticed Dr. Cook does not bind himself to saying that there are not times other than after heavy rain when the sewage is not used on the farm]. (2) "The drains leading to Napier's Park and People's Park have overflows into the Cooum, by which sewage enters the river at night, &c., so have the

* 75,000 gallons per acre.—W. G. K.

† Under such circumstances 200,000 gallons per acre have been passed with fair results.—W. G. K.

drains leading to two picottah farms of Pudupet and Dam's bridge." It is true he passes with the utmost brevity facts that are of importance, but I fancy few sanitarians would care, in dealing with a population of 450,000, to plead as little concern on the subject, with the knowledge that every drop entering the Cooum swells the stagnant mass of sewage in that elongated cesspool that winds through the very heart of inhabited areas. At any rate, these brief allusions are inappropriate in describing sewage disposal in areas that, according to Dr. Cook, "compare favourably with sewage farms in any part of the world." Photos Nos. 1 and 2 will show how each week, irrespective of occasions of rainfall, sewage that should be dealt with by one of the two farms he specifies—the Kistnamapet—is disposed of. Here is seen the Triplicane pumping station, which is worked on week days by steam and on Sundays by picottah. Between 9 and 10 on the morning of the 3rd February 1895, the stream of sewage that should have reached the Kistnamapet farm by the iron pipe spanning the bridge was found by me flowing into the Junction canal; between 5 and 6 P.M., on the same day, when the photo was taken, the stream was still flowing, in spite of work for part of the day by picottahs. Therefore, the sewage of Triplicane that should have passed to the Kistnamapet farm was disposed of on anything but sanitary principles for the best part of twenty-four hours. Until Dr. Cook can announce that all sewage intended for the Kistnamapet farm is not allowed on Sundays and other holidays to pass into the Cooum *vid* the Junction canal to the detriment of the city, few, I think, would agree with him as to the perfection he contends for. As to the remaining champion farm—the Black Town—its position on the coast prevents the non-usage of sewage at times being of any sanitary consequence. This, however, is due to the accident of its position, not to its method of working; within this limit, I consider the results secured here admirable.

Dr. Cook's further statement as to the "minor farms" in inhabited areas is also apt to mislead the reader not acquainted with the facts. He states:—"For the present, I believe they serve a useful purpose in utilizing sewage that would otherwise be discharged into the river or canals or soak into and pollute the ground." Granting that the crude sewage passes at nights, and on holidays, into the Cooum from certain of these farms, one would think, from information conveyed in Dr. Cook's paper, that this is the worst that could be said of them. It would never strike the reader, for example, that soil-soakage by sewage could occur in the immediate vicinity of sewage farms; still less, that sewage brought thither could be disposed of by soil-soakage at the cost of municipal labour—especially in view of the fact that Dr. Cook would have it he fails to understand even the significance of the term I have used. Yet, I think, Photo No. 3 sufficiently points to the existence of the condition I have defined. This represents the picottah near the Choolay Sepoy lines. The sewage is in the act of being raised, and the line of water facing the observer in the drains is distinctly shown; but, at a certain point, this line obviously ceases, and there is left to view the dry drain; simply because its contents are going to swell the pool of crude sewage shown in Photos Nos. 4 and 6 below the level of the farm (also shown in Photo No. 6) which, it is supposed, is being served. Again Photo No. 7, showing pools of sewage side by side with a picottah embankment, also exhibits how disposal by soakage is effected. Indeed, at the collecting well for this area, a pipe is placed below the embankment, on purpose to allow the overflow to go from the sewage collecting well in the direction stated. Photo No. 8 shows how, close to another picottah, the same mass of sewage is being afforded a further addition. Although not shown in these photos, on account of the interposition of trees, it must be remembered that these pools of semi-stagnant sewage are within 20 and 30 yards of thickly-inhabited areas. These increments of sewage—diluted, I grant, with surface water—make a stream which finally passes between the fearful collection of rubbish seen in Photo No. 9 and DeMellow's sewage farm. During rainfall, the mass reaches Cochrane's Canal, and thus distributes the sewage of Pursewakam and Cossipett throughout inhabited areas *vid* the Cooum. In Photo No. 10 will be seen a pool of sewage close to habitations due to leakage from the sluice-gate of the open conduit, which accommodates the sewage when backed up from DeMellow's farm on Sundays when attempts at disposal on the farm are imperfect, and at nights

throughout the year when they cease. Last year, during my inspection, I found no sluice-gate on this conduit, and the sewage extended over the whole of the ground seen in the photo and along the road towards the People's Park. In the face of these facts, I fail to understand Dr. Cook's denial of disposal of sewage by soakage on the soil, that it is the function of these sewage farms to deal with in a safe manner. If they do not fulfil this function they must forfeit the pretence of being sewage farms at all. The argument advanced that these inferior arrangements serve to prevent a certain proportion of crude sewage going where it should not, is merely begging the question. Indeed, the concession of the President and Health Officer that larger storage reservoirs are requisite in connection with these farms, is of itself a sufficient indication that my remarks are well justified.

Dr. Cook maintains, in spite of the conditions above described, that under-drainage is "unnecessary," and that the levels of "some" of these farms in inhabited areas will not permit of under-drainage; but the converse is also true. DeMellow's farm is in part under-drained, and no one can doubt, therefore, that its application throughout is feasible. Again, it is evident that the sewage plot shown in Photo No. 6 will permit of under-draining. In certain of the farm plots on the banks of the Cooum and Cochrane's Canal, it could also be applied.

If sewage farms are to take rank as sanitary works, they must be so arranged as to discharge no sewage that has not passed through the soil or over the soil, — in the latter case only after prolonged contact, proved by a series of analysis, during a considerable period, in the case of each farm, to be sufficient. If the ground at disposal at any point — for example, at Perambur Barrack Road bridge—be too limited to receive all the sewage, mere farming should be abandoned, and the sewage should be submitted to a correctly-prepared under-drained sewage-filter which would fulfil requirements. Indeed, although, as I have already stated, I had no intention of recommending under-drainage or any improvement in farms that at the time of my writing my Annual Report I hoped would be abolished, in the absence of the possibility of Mr. Cousins' scheme being completely effected, I would now advise that in each sewage farm near inhabited areas, in addition to plots for irrigation, special portions should be under-drained and prepared as sewage-filters to receive flow during rainfall, and when it is not required for the crops. As a necessary adjunct, either the collecting reservoirs should be enlarged as suggested by the President, or, what is better, labour should be employed for sewage-lifting during a greater part of the twenty-four hours than at present; or, as circumstances demanded in individual cases with regard to efficiency and economy, both arrangements should be adopted. This probably, in the case of Madras, is a fair compromise, with a sewage system within measurable distance; but, putting aside this special case and dealing with the general principles which Dr. Cook enunciates, I regard it as essential that where a public body is compelled to dispose of sewage on a farm *within inhabited areas*, as a result of the absence of a correct sewerage system, it also should do its best to protect the inhabitants by arranging for under-drainage, not only with the object of removing effluent, but of accomplishing purification in the most complete manner reasonable and practicable. It seems to me that it is due to a failure to appreciate the full importance of using the best means available, that I am indebted to the Health Officer for his protest. The securing of circulation in the soil by under-drainage where purity of effluent is aimed at, especially on limited areas, is as essential as respiration to a human being, to which function the access of oxygen to the soil voids, enabling nitrification to be effected, has been aptly compared.

I see no reason whatsoever, from a perusal of Dr. Cook's Medical Congress paper, to modify my opinions that, whilst the Madras Municipality have so managed their farms as to prove them a financial success, these are worked on very bad sanitary principles; it being absurd to suppose that a sewage farm meets sanitary requirements unless it is capable of disposing with safety to the population *on its soil at all times* *all* sewage intended to be dealt with by it. Of what utility, except for economic purposes, can a sewage farm be which every seventh day refuses to purify its sewage, and pours it in a crude state into a stagnant pool that extends through the breadth of

a thickly-inhabited city! In short, all that can be said as to their management is that farming with sewage is pursued — not *sewage farming* in the sense accepted by sanitarians.

(Signed) W. G. KING, Surgn.-Lt.-Col.,
Ag. Sanitary Commissioner for Madras,
Secretary (General Sanitation Department), Sanitary Board.

6th February 1895.

ORDER—dated 10th May 1895, No. 818 M., Local and Municipal.

The memorandum of the Sanitary Commissioner will be forwarded to the President for consideration.

2. It is understood that a committee of the Commissioners is now sitting to deal with the question of improving the existing system of drainage and that the main feature of the recommendations which it will make will be the introduction of the back-bone drains of Mr. Cousin's scheme without, for the present, the subsidiary drains and house connections. If this plan is introduced it will probably be possible to get rid of the small sewage farms which are scattered about the town and to concentrate all sewage farming on one spot.

3. But in the meantime measures to effectually stop the soakage to which Dr. King alludes should be taken and proposals for preventing the flow of any sewage into the Cooum should be considered and estimated for and the result reported to Government.

4. His Excellency in Council is not prepared to admit that under-draining of sewage farms is unnecessary. Of course if the scheme referred to in paragraph 2 *supra* is carried out with the result that the smaller sewage farms are abandoned, it will not be necessary to go to any large expense in under-draining these, though, as it will be some time before any improvement in the existing drainage system can be executed, it would be advisable, wherever under-drainage is manifestly necessary, to carry it out at once as economically as possible, soakage being in all cases promptly dealt with. Whatever course, however, is followed as regards the drainage of Madras the large farm north of Black Town will remain, and Government is of opinion that very early steps to under-drain this and discharge the resulting effluent into the sea should be taken.

(True Extract.)

Chief Secretary.

To the President, Municipal Commission, Madras.
" Sanitary Commissioner.

Exd. A. Railt.

Govt. of {1895} Madras.

LOCAL AND MUNICIPAL.

Issued

Recd. *Encl.*

G.O., 10th May 1895, No. 818 M.

MAY.

Madras Sewage Farms.

Communicating to the President, Municipal Commission, Madras, with remarks, the memorandum of the Sanitary Commissioner in connection with sewage farming in Madras.

GOVERNMENT OF MADRAS.

LOCAL AND MUNICIPAL DEPARTMENT.

READ—the following paper:—

From Lieutenant-Colonel G. M. J. MOORE, C.I.E., President, Municipal Commission, to the Chief Secretary to Government, dated Madras, 3rd December 1894, G. No. 495.

With reference to G.O., dated 26th October 1894, No. 2189 L., Local and Municipal, I have the honour to forward the accompanying letter from the Health Officer together with the paper referred to therein.

2. It is unnecessary for me to offer any remarks on what is purely a professional matter, except to say that the storage capacity of the wells will be increased, so that there may be no overflow of sewage at night.

ENCLOSURES.

From Dr. J. NIELD COOK, Health Officer, to the President, Madras Municipal Commission, dated Madras, 27th November 1894.

Concerning the comments on the Madras sewage farms contained in the annual report of the Sanitary Commissioner of Madras for 1893, referred for report in G.O., dated 26th October 1894, No. 2189 L., Local and Municipal, I have the honour to offer the following remarks.

2. In the few lines devoted to the subject the Sanitary Commissioner inferentially expresses very decided opinions. As I am unable to accept his conclusions and a mere expression of my opinion is not likely to weigh with Government against that of their own Sanitary adviser, I beg to submit a copy of a paper written for the Indian Medical Congress, in which I have dealt with the matter at some length (*vide* pages 19 to 25).

3. I consider that under-drainage is unnecessary, as the ground is perfectly permeable and the purified sewage will not cause pollution, and that the discharge of the effluent from the proposed drains is impracticable in the case of some of the farms on account of their levels. Discharge of sewage into the Cooum only occurs in the case of some of the smaller farms principally at night when the picottahs cannot well be worked. The amount is not large, as much less sewage flows at night than during the day. The Commissioners propose to deal with it by providing cisterns or storage tanks into which the sewage can flow until pumping is recommenced. The objection to this is that in a hot climate sewage rapidly decomposes, so that there is likely to be some nuisance from the stored sewage. I am unaware of any such thing as disposal by soakage in connection with the sewage farms. Any soakage which occurs is in consequence of faulty drains. If it were not for the presence of sewage farms in inhabited areas, disposal by discharge into the Cooum and by soakage would be the rule rather than the exception. With the introduction of a good system of sewerage capable of carrying all the sewage to the north of the town, the disposal of it could be arranged for by the extension of the Black Town farm and the difficulties now experienced would disappear.

Sewage Farming in Madras and the suitability of the system for India—By J. Nield Cook.

How to dispose of sewage has always been a problem of paramount importance. I do not propose to discuss the laws of Manu or Moses or matters of ancient history. For my present purpose sanitation may be said to have commenced in the latter half of the century. In 1857, the Royal Sewage Commissioners laid it down as an axiom that "the right way to dispose of town sewage is to apply it continuously to land." However, considerable difficulties were experienced in putting the principle into practice. The heavy soils found in most parts of England, the abundant rainfall throughout the greater part of the year, the low temperature during the winter months when vegetable life is practically at a standstill, and the difficulty and expense of acquiring suitable lands of sufficient extent in the natural direction of the drainage, have prevented the application of the sewage to the land becoming in any sense general. In 1875, the committee appointed by the Local Government Board to inquire into the various methods of sewage disposal reported "that land irrigation is not practicable in all cases." The object of this paper is to show that the adverse conditions which prevented the general adoption of this method of disposing of town sewage in England are for the most part absent in India. A trial extending over a quarter of a century has been made in Madras, where the local conditions are in no way exceptionally favorable, and has proved that an almost unlimited amount of sewage can be disposed of in this way in accordance with the best hygienic principles, and further that the produce of the farms finds a ready market and realizes a handsome profit on the outlay. At the same time I hope to give such practical details as will enable any one to make a more or less extended trial of the system with good prospects of success.

The idea of adopting land irrigation as the means of disposing of sewage in Madras was conceived by Mr. Standish Lee, the Municipal Engineer, in the year 1869. No worse site could have been found anywhere about Madras than that of the first experiment. This was in the neighbourhood of Chulay, and is now known as the D'Mellow's Road farm. It was a dismal swamp, periodically submerged by salt water, which on evaporation deposited a saline mud. The soil was black, plastic and as retentive as stiff clay. Not even a blade of grass grew there. Operations were commenced in June 1869. The swamp was reclaimed by depositing street sweepings and was planted with guinea grass. Some crops were obtained, but subsequently difficulties were encountered. With the advent of the hot weather of 1870 evaporation increased considerably, and salt was drawn to the surface forming a saline efflorescence if the ground was allowed to rest a few days. A large quantity of guinea grass perished, and some harriali, or dhoob, that had been planted, was not strong. A coarse swamp grass sprang up, which is known as cow grass (*Chloris barbata*), and is liked by cattle though unsuitable for horses. Moreover, the surface sank irregularly, throwing out the grading of the beds and necessitating a large amount of manual labour. Later on an inspection was made by an agricultural expert, who traced the main cause of the want of success to the sub-soil water, which was found in some parts of the farm at from four inches to two feet from the surface. The worst parts of the farm were under-drained at intervals of six feet with pipes running four feet from the surface, which was raised by the deposit of rubbish, and after this no further difficulty was experienced. My own opinion is that the drain pipes in this case were of little or no use, as they were placed below the level of the sub-soil water and had no outlet. The whole neighbourhood is low and swampy and at the present time water is found at from eighteen inches to two feet from the surface.

The next experiment was made in 1870 at Krishnampett near the sea-shore. Half the land taken up consisted of pure sea-sand, the remainder of land which had been reclaimed with rubbish and covered with a thin stratum of sand. Here no difficulty was encountered, the soil being porous and permitting the great desideratum of sewage farming—free downward percolation. Heavy crops were soon raised amounting in 1871–72 to about 69 tons of grass per acre. Since then a number of farms have been started, the principal one being known as the Black Town farm. This is admirably situated on the beach $2\frac{1}{2}$ miles north of the town. It is so close to the shore that last year a considerable portion of it was carried away by a heavy

sea. The farms now in use and the areas they drain are shown in dark and light colors on the accompanying map. It will be noticed that some of them are in inhabited areas and are of comparatively small size. This is due to the want of any general system of drainage in the town. In my opinion the fundamental principle for any system of sewerage for Madras should be to carry all the sewage to the north and dispose of it on one large farm, which could be made by the extension of the present Black Town farm. This would be more economical and in other ways preferable to having a number of small farms scattered over the town.

Successful sewage-farming is to a considerable extent dependent on physical conditions. The geology and surface of Madras are thus described in a recent report by Mr. Edward Cousins, C.E.:—"The surface and sub-soil consists, as a rule, of deposits of white and grey sand in which occur at irregular intervals thin beds of clay. Water is found below the surface at varying depths but generally in the low-lying parts of the districts it corresponds with the mean level of the sea. At no part of this sandy plain are there any considerable elevations of the surface, the maximum heights are from 20 to 24 feet above mean sea level, while many portions of the town are only two feet to six feet above that level. The average elevation of the surface may be taken at about nine or ten feet." The higher parts of the town, being principally occupied by private houses with large compounds, have no drainage system, provision only being made for storm water. The parts providing sewage to be disposed of are all if anything below the average height given, which necessitates the lifting of the sewage by pumps, either from central pumping stations or from wells on the farms, which is a costly undertaking. At first only the water-lift of the country was used. This is known as the 'picottah' and consists of a lever balanced on a strong upright and worked up and down by men stepping from one side of the fulcrum to the other. But for any kind of manual pumping to be successful constant supervision is required, and now for the principal farms this primitive system has been superseded by the steam-pump, which is in every way more satisfactory. Gwynne centrifugal pumps have been found to answer best. The Ráyapuram pumping station, from which the sewage of Black Town is pumped to the Black Town farm, is fitted with three of them, each fifteen inches in diameter. The sewage is lifted from a well, into which three sewers empty their contents, and discharged into a cast-iron main 24 inches in diameter and about a mile and a third in length, being carried the remainder of the distance of $2\frac{1}{2}$ miles in an open masonry channel. No further lifting is required after the sewage reaches the farm. Pumping at this station is carried on on an average $22\frac{1}{2}$ hours daily, the amount of sewage pumped being about three million gallons. Night-soil is removed on the pail system and is not supposed to enter the drains, though the urine and washings of the latrines do so. The annual rainfall varies considerably, the average being about fifty inches, which is above the general average for India. A very large proportion of it falls between the middle of October and the middle of December."

As I consider the Black Town farm to be a fair model for an Indian sewage farm, I shall describe it somewhat in detail. The general arrangement is shown in the accompanying plan. The sewage passes from the outfall channel through culverts with sluices into the main carriers. These are banks of earth with a channel scooped out on the top. They run in parallel lines about 432 feet apart, giving off at right angles the secondary or distributing carriers, which are similar but somewhat smaller. The interval between the distributing carriers is 114 feet, and it is divided into two by a small bund, which runs through the beds half-way between them. This may be called the central bund. The beds slope down to it from the distributing carriers. It is absent in some of the farms, but I think it is a good thing to have it, as the grass may rot at the lowest part of the slope through the water standing there longest. It percolates through the bund, and so this is avoided. There are further bunds at intervals of six to eight feet running from near the distributing carriers down to the central bund. These are small and not more than four to six inches in height. They conduce to the equal distribution of the sewage over the grass. The junction of a distributing carrier with a main is made with a stoneware drain pipe of about six inches diameter. Grass grows freely over the bunds and over the carriers to the very edge of the channels, which become coated with a black sludge, which

hinders the sewage from sinking in though it allows enough percolation to keep the grass growing freely over them. Large drain tiles have been laid in some of the carriers, but they soon get displaced and serve no good purpose. The gradient of the carriers should be sufficient to ensure a fairly rapid flow without causing a scour. Where the amount of sewage to be disposed of is small, the beds should be made somewhat smaller than the measurements I have given, in order to get even distribution. The slope from the distributing carrier to the central bund is about 1 in 30.

The system of irrigation which has been found to answer best is to flood the beds heavily every three or four days, though it can be done oftener without any ill-effect. The method employed is to open the sluice in the outfall channel and let the sewage run into a main carrier. The drain pipes leading to the distributors to be used are left open; those which are not to be used are closed with earth and grass. If only the first part of a main carrier is required it can be bunded across at the required distance with earth. The same can be done with a distributor, which is then breached behind the barrier, and the sewage pours out and runs down the space between the distributor and the ends of the bunds that divide up the beds, and turns off between these bunds to run down the beds to the central bund. The men in charge of the farms say that they put on about four inches at a time, but the amount must be much larger as a good deal of sewage sinks in before it begins to lie on the surface. This method of intermittent irrigation economises the labour on a large farm, as only a third or a quarter of it has to be attended to every day. It also gives plenty of time for air to be drawn into the interstices of the soil and provide the oxygen which is necessary both for nitrification and the formation of tissue. Most cultivators irrigate equally all the time a crop is growing, but one of great experience told me that the younger the grass the more sewage it would take. The grass should not be irrigated for two or three days before it is cut. This allows it to harden, and though it does not weigh quite so much its quality is better and it does not wither so quickly. After the grass is cut, which is done in Madras with a sickle with a saw edge, the teeth being set the contrary way to an English saw, the ground should lie fallow for the best part of a week. The careful farmer will then take the opportunity of forking it and loosening the roots, though in some farms this is not done more than once a year. It favours the development of young roots to replace the old ones, and so preserves a healthy and vigorous growth. The beds should also be weeded. If this is done regularly it entails very little labour, but if it is neglected there may be some difficulty experienced. The grass is generally cut rather before it reaches maturity. The contractor reckons to cut a crop every 45 days, which gives eight crops a year. In the Municipal parks, where sewage irrigation is carried on, we do not get quite so many. The method of irrigation by blocking the channels with earth and breaching them is primitive, but it suits the native cultivator, who is very skilful with it, and it has been found to answer the purpose, so no attempt has been made to supersede it and introduce iron or wooden stoppers.

Some of the three million gallons of sewage daily pumped at the Ráyapuram station is drawn off to irrigate the Robinson Park, the remainder goes to the Black Town farms. Adding together the area of the park, the farm, and of certain private lands adjoining the farm which are irrigated by the contractor, we get a total of forty acres approximately. This gives a daily average of 75,000 gallons per acre. The experience of the Berlin farms is that not more than 2,000 to 3,000 gallons of daily sewage should be allotted per acre, so that the land may have the necessary periods of rest. At the Bedford farm in England about 5,200 gallons per acre are pumped daily and at the Beddington farm about 6,600 gallons, which is the largest amount I know of outside Madras. Yet the Madras contractor, who is getting twelve times as much sewage per acre as any European farm would stand, recently petitioned to have sewage irrigation stopped in the Robinson Park on the ground that he was not getting enough. This is a remarkable testimony to the porosity of the soil and the copious evaporation and transpiration that take place under the influence of the Indian sun. At times when I have visited the farm, especially after heavy rain, all the sewage was not being used, the surplus running into the sea at a point beyond the farm. The sewage which is used to irrigate the farm does not form a definite effluent,

but on careful examination I have found tiny rivulets trickling down from near the bottom of the wall of sand in which the farm ends where it drops down to join the sea-shore. The amount is so small that it was a long time before I noticed it.

As regards the crops that do best, though it has been found that nearly everything will grow under sewage irrigation, later experience has confirmed the verdict of the early experimenters in Madras, that harriali grass (*Cynodon Dactylon*, Hind.: Dhoob) is by far the most satisfactory. It has the advantage of being indigenous, for English and French experience has shown that the peculiar crop, whatever it may be, that suits the neighbourhood, seems to flourish under sewage. It is, moreover, a voracious feeder, and is not easily killed by excess of sewage. In the wild state in places where there is not much moisture it creeps for the most part below the surface of the ground. Native ponies may be seen scraping the surface of the ground with their hoofs and blowing away the dust to get at it, and will graze where there is not a blade of green grass to be seen. But, when abundantly irrigated it shoots up to a height of two feet or more and yields most luxuriant crops. Captain Horace Hayes, F.R.C.V.S., says of it in his book on "Horse Management in India": "In good soil when cultivated it loses its creeping character and grows like English meadow grass, to which I think it is much superior." A good farm yields about 45 tons of green grass per acre, which dries down to about 15 tons of hay. This compares very favourably with the Berlin farms, which yield 25 tons of grass or 5 tons of hay. From this it would appear that the grass grown in Madras contains less water than that grown in Germany. The English sewage farms yield about the same amount of hay as the German ones. This is about double the yield from English meadow land. So where we get one ton of hay from meadow land, we get two tons from European sewage farms and six tons from Madras sewage farms. This enormous difference may partly be attributed to the season of growth being continuous in India, whereas in Europe it is limited to the summer months, and partly to the fact that a high temperature in a soil or water up to 99° Fahrenheit increases the activity of nitrification and consequently of vegetable growth. The hay from the Madras farms is mostly sold to the Commissariat at Rs. 45 a ton. This gives an average money yield of Rs. 675, or about £37 sterling per acre, taking Rs. 18 to the pound, against £18 per acre, which is reported to be the average price of Italian rye grass grown on the Bedford sewage farm. When the differences in the cost of land and labour in the two countries are taken into account, it is easily seen how it comes to pass that sewage farming is so much more profitable in India than in England, for we have double the produce on probably less than a quarter the outlay. Besides the supply of hay to the Commissariat there is a fair market for grass and hay among horse-owners in the city, especially during the hot weather when grass is scarce.

With regard to the quality of our sewage-farm hay as forage, I wrote to Veterinary Major W. Gladstone, A.V.D., the officer in charge of the horses of His Excellency the Governor's Body Guard and the Royal Artillery at Saint Thomas' Mount, who replied:—

"Since hay from the sewage farms has been used at the Mount there has not been a single case of anthrax until this year, when on inquiry I found that one of the Majors was using grass-cutters' grass. This was stopped and since then we have not had a case. The same in the Body Guard. I strongly recommend hay from the sewage farms, as diseased cattle are not allowed to stray over the land, and it is by far the best forage you can get in Madras. Veterinary Colonel I. S. Shaw says that wherever dry hay has been used anthrax has not been known, and certainly I have not seen a case. In Belgaum in 1878 we had anthrax, and as soon as the grass-cutters were discharged it ceased and has not recurred since. The same in Bangalore, except when they are compelled to use green grass, as in camps of exercise, &c. So I believe the drying process and keeping diseased cattle off the land has a great deal to do with this immunity."

Other Veterinary Surgeons with whom I have discussed the matter have spoken equally in favour of sewage-farm hay.

Harriali grass grows better from roots than from seed. The roots should be planted in rows about six inches apart. It spreads quickly and in about two months a light crop can be cut. If it is planted in a soil recently made by the deposit of rubbish

the irrigation should be somewhat excessive; daily will not be too often. Otherwise the heat due to fermentation may kill the grass. It is advisable to let rubbish rest for six months or more before planting it, otherwise the level of the beds may be thrown out through its sinking irregularly. After planting, if the beds keep their level, there is nothing further to be done beyond weeding and forking. Beds, both of sand and of made soil, planted more than 20 years ago, are still yielding good crops, though, so far as I know, they have never been ploughed up or replanted. If a bed sinks in any part, a few cart-loads of rubbish will restore the level. If caterpillars appear, as they occasionally do about the end of the rainy season, a little freshly slaked lime will quickly put an end to them, failing which ashes are as good as anything.

About 50 acres of land are leased to a contractor. The amount was larger, but two farms have been abolished as the sewage supplied to them was carried to the Black Town farm after the opening of No. 2 sewer, and a considerable portion of the Black Town farm was carried away last year by the sea. Eleven acres more are being acquired, to be added to the Black Town farm. The contractor also irrigates about 20 acres of private land, part of which he leases from the owners and part he holds under an agreement with the Commissariat. The land in three public parks which is worked departmentally brings the total area up to about 100 acres.

Complaints of nuisance have been made against some of the Madras farms as against most sewage farms in other places. There is an ammoniacal smell from the sewage wells and main carriers at times, but apart from this the air over the farms themselves seems perfectly fresh and wholesome. No one with his eyes bandaged could perceive by the sense of smell that he was walking over a sewage farm. With regard to the sanitary aspect of the question there have always been differences of opinion. The Sanitary Commissioner for Madras appears to have a bad opinion of the Madras farms. For in his annual report for 1893, page 115, he writes: "Madras town pursues the system profitably but on bad sanitary principles; the sites being often within inhabited areas, no arrangement being made for underdraining and discharge of the effluent and in certain cases disposal by soakage in the neighbourhood or discharge into the Cooum being allowed during intermitting working of the pumping machinery." For my own part I think the Black Town and Kristnampet farms would compare favorably with farms in any part of the world. I cannot understand on what ground a charge of bad sanitary principle can be preferred against them. With regard to some of the farms being within inhabited areas, I have not found that the health of the people living near them is worse than elsewhere. Taking cholera as a disease specially prone to appear under insanitary conditions, spot maps showing the mortality do not indicate that the disease has shown a special preference for the neighbourhood of the farms. There is nothing to show that diarrhœa, dysentery, typhoid, or diphtheria specially affect these localities. Dr. Alfred Carpenter, who has had a practical experience of 30 years or more and made a special study of the question in connection with the English farms, lays it down as a proposition "that the judicious application of sewage in close proximity to dwelling-houses does not depreciate the health of the inhabitants." "In no single instance," he said on one occasion, "out of nearly 100 cases in which sewage has been utilized by broad irrigation has any fact been proved to establish the allegations of 'insanitariness' which are sometimes brought against them." There is a Female Orphan Asylum with 200 inmates on the border of the Croydon farm and the health of the children is said to be unaffected. Many Lunatic Asylums utilize their sewage on their own grounds with excellent results. The General Hospital, Madras, has diverted its sewage from the river Cooum and employs it to irrigate a strip of land close to some of the buildings. The result is a vast improvement to the appearance of the place, and I have not heard that any complaints have been received from the Medical or Surgical staff that the health of their patients has been injuriously affected. I think they give Surgeon-Colonel Price considerable credit for the innovation. It will be seen from the map that most of the farms within inhabited areas are small. Most of them are irrigated only by means of picottahs, which limits the supply, and I believe that in India unless the supply is very abundant very little, if any, water reaches the sub-soil water. These farms will doubtless be abolished and the Black Town farm

extended when a comprehensive system of sewerage is introduced. For the present I believe they serve a useful purpose in utilizing sewage that would otherwise be discharged into the river or canals or soak into and pollute the ground. With regard to under-drainage, its objects are to prevent the soil from becoming water-logged, which ruins the crops and prevents the proper exercise of its purifying action on sewage, and to enable a larger quantity of liquid to be disposed of. It has never been successfully employed in Indian agricultural operations. In a trial made at the Saidapet experimental farm it was found that its efficiency was destroyed through the pipes getting blocked by white ants, &c. It is quite unnecessary in a highly permeable soil that permits free percolation. In the Berlin farms it was not adopted at first, but was subsequently resorted to when the soil got water-logged, 2-inch pipes being laid 16 to 33 feet apart at an average depth of three to four feet. In most of the Madras farms there is no water to be found under five or six feet and I have dug down to a depth of ten feet close to where irrigation was being carried on without getting any accumulation. There is no impervious stratum under them for a considerable distance down, D'Mellow's road being an exception, as it has an impervious stratum and is only slightly raised above the surrounding swamp. In England and Germany it is found that less than half the sewage used for irrigation flows away as an effluent. In India the proportion must be very much less, as evaporation and transpiration are enormously increased under the influence of the tropical heat.*

This enables us to use large volumes of sewage for irrigation without underdraining and without appreciably raising the level of the sub-soil water. I know of an instance in which a small sewage farm was started which was irrigated daily. A well within a few yards of the farm, which was used for irrigating a plot of grass, had to be deepened to get water enough for the purpose, which would not have been necessary if the sub-soil water level had been raised by the percolation of sewage through the ground exceeding the amount given off by evaporation and transpiration. In India, if the sewage to be disposed of is too much for the land, it is better, where it is possible, to extend the farms, rather than to increase the effluent by underdrainage. The drains leading to the Napier Park and People's Park have over-flows into the Cooum, by which sewage enters the river at night, when the pumps are at rest, or during heavy rains. So have the drains leading to two small picottah farms, Pudupet and Dam's road. It is proposed to introduce storage tanks to intercept the sewage that now escapes into the river, which is inconsiderable in amount. I do not know what is referred to by disposal by soakage. In some parts of the town there is soakage, but this is due to the want of proper drains and not to sewage-farming on bad sanitary principles. Sewage-farming can only be held responsible for the disposal of sewage when it reaches its destination and not for defects in the sewerage and drainage of a town.

The price paid for land for sewage-farming in Madras has not been high, and from what I have seen of other Indian towns, I believe that cheap land suitable for the purpose would generally be procurable. In the Madras farms there are practically only two types of soil—sand and made soil. They are both porous in a high degree and to about an equal extent. To test their porosity and their purifying action on sewage I recently performed some simple experiments. I had four filters or guages

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* Some idea of this can be got from the following extract from a paper by Messrs. Dawes, Gilbert and Warrington in the Journal of the Royal Agricultural Society of England, 1881:—

"As the transpiration of water in a plant is determined by light, the amount of transpiration must have some connection with the rate of assimilation and growth. When the supply of water and of soluble plant food is tolerably constant, the relation between transpiration and growth will be fairly regular. From experiments made at Rothamstead many years ago with plants grown in pots it was concluded that from 250 to 300 lb. of water were evaporated for 1 lb. of dry matter added to a plant. It may be, however, that in a soil poor in soluble plant food a larger amount would pass through the crop to yield the same amount of assimilation than in a soil well manured. The relation between transpiration and assimilation will indeed probably differ under different circumstances."

The soil in the Black Town farm containing practically no soluble plant food, the amount of water transpired might be expected to be large. Taking into account the intense brightness of the sun light it would probably be within the mark to estimate it at double the amount given above. An acre yields 15 tons of dry matter. This would give 15 × 600 tons of water transpired.

9,000 tons = 20,160,000 lb., or 2,016,000 gallons per annum = $\frac{2,016,000}{365}$ gallons a day = 5,523 gallons a day.

The amount lost by evaporation in India which averages 0·22 of an inch should be added to this. This is 49,280 gallons an acre and is probably more than actually evaporates, as water is not always standing on the beds. On this reckoning transpiration and evaporation together would daily amount to 54,803 gallons per acre, or more than two-thirds of the sewage water allowed for irrigation. 21,197 gallons would be left to join the sub-soil water. The amount lost by transpiration is probably more than the estimate taken.

made, each consisting of three 9-inch drain pipes joined together and cemented so as to form impervious cylinders rather more than six feet in length. These were placed perpendicularly on wooden stands with perforated iron plates intervening and galvanized iron buckets placed underneath. Two of these I filled with earth from the Robinson Park and the other two with sand from the Black Town farm, first putting a few pebbles and pieces of broken pot at the bottom. On the top I put grass from the farms, partly as I believed it would act as a strainer, partly in order to obtain any action the roots might have upon the sewage as it passed over them, and generally to reproduce as nearly as possible the natural conditions of a farm. The soil of the Robinson Park was originally street sweepings; it is now a rich and friable loam of a dark brown colour. The soil of the Black Town farm was originally sea-sand, and as far as its physical characters are concerned it has practically undergone no alteration though subjected to sewage irrigation for over a decade. I put sewage in at the top and caught the effluent water in the buckets at the bottom. The time taken by the sewage to pass through varied somewhat, its first appearance being in two to three hours when the soil was comparatively dry and half to one hour when it was fairly moist at the time of starting the experiment. It passed through the made soil quite as quickly as through the sand, which was contrary to expectation. I began by putting two gallons of sewage, pint by pint, into each filter. About half of it was absorbed by the soil almost immediately, the remainder stood on the surface and percolated down much more gradually. As soon as it began to come through the first filter I added a gallon more to each in order to get enough effluent for analysis. I sent samples of the sewage used, which was taken from the well in the Ráyapuram pumping station, and of the effluents, to Surgeon-Major J. L. VanGeyzel, M.B., F.C.S., &c., Chemical Examiner to Government, who very kindly analysed them for me. The following are the results of his analysis:—

ANALYSIS.

Parts per 100,000.

—	Suspended solids.			Dissolved solids.			Chlorine.	Free ammonia.	Albumenoid ammonia.	Nitric acid.
	Organic.	Inorganic.	Total.	Organic.	Inorganic.	Total.				
Filtered effluent sandy soil from Black Town Sewage Farm	0·100	1·600	1·700	205·000	555·000	760·000	269·800	0·120	0·220	8·670
Sewage from Ráyapuram Pumping Station ..	12·700	19·700	32·400	66·000	299·000	365·000	170·400	5·200	0·560	0·210
Filtered effluent (No. 1 Filter) made soil from Robinson Park Sewage Farm	Trace.	0·200	0·200	117·000	304·000	421·000	138·400	0·024	0·056	16·920
Filtered effluent (No. 2 Filter) made soil from Robinson Park Sewage Farm	Trace.	0·400	0·400	105·000	280·000	385·000	120·700	0·019	0·064	16·500

The character or source of the organic matter cannot well be inferred from the above analysis in the absence of determinations of the amount of organic carbon and nitrogen present. Owing to the short space of time unavoidably allowed to the analyst, these determinations had to be omitted. The filtration performed in the experiments was necessarily imperfect. The soil in the filters was much less compact than that in the farms, where it had been rained upon and irrigated for years. If I had had the means available of isolating sections of the farms without disturbing the soil and had been able to utilize a larger area in proportion to the sewage used, I believe that the effluents obtained would have been purer. The sewage put on—2 gallons to an area of 63·6 square inches—is equivalent to 591,750 gallons an acre, which is seven times as much as the average daily amount used on the Black Town farm, or more than twice the amount used at a flooding done every three days. The sample

of sewage analysed contained rather less suspended matters and free ammonia, much less combined ammonia and much more matters in solution and chlorine than are contained in English sewage of average composition. At the same time, the results obtained amply demonstrate the purifying powers of the soil and are in the main in accordance with the results of English experiments. The effluent water was clear, odourless and practically colourless. The analyses show that it contains less suspended organic impurities and much less free and albumenoid ammonia than the sub-soil water in parts of Black Town of which I have analyses. It would so far pass the standards of purity adopted by the Commissioners appointed to inquire into the best means of preventing the pollution of rivers. The most noteworthy point, whether from the point of view of the sanitarian or of the agriculturist, is the retention by the soil of the suspended organic matter and ammonia in solution and the appearance in the effluent of nitrates. According to modern theories based on the experiments of M. M. Schlæsing and Muntz and Messrs. Lawes, Gilbert and Warrington, this is due to nitrification brought about by the presence of living organisms, which specially occupy the first 18 inches of the top soil. The vital activity of these living ferments varies with the temperature, being very low near freezing point and reaching its maximum at 99° Fahr. I have not got reliable records of soil temperatures in Madras, but a few days ago (early in November) I took some temperatures of the soil on the Black Town farm in the early morning, which were over 80° Fahr., so that that it is probably between 80° and 100° Fahr. generally, which is the most favorable temperature for the process, and so in the highest degree conducive to the purification of sewage. In a paper read before the Society of Arts in 1882, Mr. Warrington pointed out that "a filtering medium of pure sand and limestone, treated intermittently with sewage, will after a time display considerable purifying powers, the surfaces becoming covered with oxydising organisms derived from the sewage. No such medium will, however, equal in effect a porous soil rich in organic life." This explains what might seem strange in the results of the analysis, that the effluent from the made soil contains much less unoxydised nitrogen than that from the sand. The experiments of the Rivers Pollution Commissioners with soils from different farms appear to show that the cleansing power of a soil is more closely connected with physical conditions as regards porosity and fineness of division than with its chemical composition; and of two soils not differing very widely in chemical composition, namely Hambrook and Dursley, one (the latter) was found to have twice the purifying power of the other. Judging from my experiments it would appear that made soil, which is the finer and richer of the two, had a greater purifying power than sand, and, as the porosity is about equal, though both are admirably suited for sewage-farming, where both were available made soil should be taken by preference, or sand might be covered with sweepings to a height of one or two feet to give it a more active nitrifying surface stratum. Presumably the nitrates in the effluent were in the soil when it was taken from the farm and were the result of former nitrification and not produced from the organic matter and ammonia in the sewage used in the experiments. The large amount of chlorides is probably due partly to the urine contained in the sewage and partly to the proximity of the sea. The amount in the effluent from the Black Town farm soil, which was taken from a spot about 200 yards from the sea-shore, was more than double that of the Robinson Park, which is more than half-a-mile from the sea. These experiments, imperfect as they were, and the analysis made by Dr. VanGeyzel, convince me that what little effluent percolates through our farms may safely be allowed to join the sub-soil water without any fear of polluting it or in any way endangering the public health. I have already shown good reason for believing that there is not very much of it, that the water-level is not appreciably raised, and that the crops are healthy and vigorous. Hence, so far as I can see, no reason exists for underdrainage, which would, moreover, entail great difficulties and expense; for the ground is in many of the farms so level that the effluent would not run off, so that it would have to be pumped, and there would be nowhere for it to go to unless it were thrown on to the beds again and so be sent round and round in a vicious circle.

Under the arrangement with the sewage-farm contractor the Municipal Commissioners undertake to pay the rent, establishment and labour. The contractor must keep in repair the sewers, drains, cisterms, channel-pipes and other things connected with the delivery of sewage in or on the farms. He must dispose of as much sewage on the

land as the Commissioners deliver. He must cultivate and manage the farms in the most approved manner and keep them in a clean condition, free from weeds, &c. He must allow free access to the farms to the officers and servants of the Municipality, in order that they may see in what state the farms are kept and whether any part is in need of repair, &c.; if so, to give notice to the lessee, who must execute the repairs within fifteen days. The contractor has the right of constructing new wells, cisterns, &c., if he first obtains consent for the proposed work. The Commissioners agree not to stop the delivery of sewage at any one time for a longer period than five days. The contractor is allowed to cultivate or irrigate with sewage other land than municipal land with the consent of the President, and pays to the Commissioners Rs. 250 per cawnie (1 cawnie = 1·322 acres) per annum for lands so cultivated. The contractor has to cultivate and irrigate any other land acquired, rented or handed over to the Municipality, and pays the Commissioners Rs. 300 per cawnie per annum for lands so cultivated. The contractor makes a deposit of a Government of India promissory note for Rs. 4,750 as security. Deductions may be made from this in the event of a breach of contract.

The contract system which was introduced in 1888 has been found to be more profitable than working the farms departmentally. The usual objection to it is that a contractor has an eye only to profit and will not use all the sewage on the farms for fear of injuring his crops. No trouble has been experienced from this cause in Madras, partly through the voracity of harriali and partly through the well-known prodigality of the Indian cultivator in the matter of irrigation. One contractor allowed weeds and objectionable kinds of grass to gain ground, especially a kind of swamp grass with strong interlacing roots (*Panicum fluitans*) which gained a hold in the D'Mellow's Road farm, and to a less extent cow grass (*Chloris barbata*).

The farms are put up to public auction triennially. At the first sale in 1888 Rs. 7,250 per annum, or Rs. 21,750 for the whole period, was the highest bid. On this, if the cost of pumping on the farms be included, there was a loss on the three years as shown below:—

Income.	Rs.	A.	P.	*Expenditure.*	Rs.	A.	P.
Rent of farms	21,750	0	0	Establishment	1,920	1	9
				Overtime	153	10	8
				Fitters staff	721	1	3
				Labour (including pumping) ..	35,414	5	10
Loss	19,239	11	6	Rent of sewage farms ..	2,780	8	6
	40,989	11	6		40,989	11	6

This shows a loss of Rs. 19,239–11–6, or rather more than Rs. 6,000 a year. In 1891 the better price of Rs. 15,600 per annum, or Rs. 46,800 for the three years, was obtained. On this an actual profit of Rs. 18,307 was realised, the expenditure having been somewhat reduced. In 1894 the farms were let for Rs. 19,000 per annum or Rs. 57,000 for the three years. The following is an estimate of the income and expenditure for the period:—

Income.	Rs.	*Expenditure.*	Rs.
Rent of farms	57,000	Rent, maintenance, &c.	30,630
Private land	14,850		
Added land (2½ years)	5,312	Profit	46,532
Total ..	77,162	Total ..	77,162

The estimated profit for the period is thus seen to amount to Rs. 46,532.

The conclusions I draw from the evidence adduced are as follows:—

(1) Barren land can be acquired at a moderate cost in the vicinity of most Indian towns.

(2) No matter how barren the land is, if it is permeable, it can be utilized for the formation of sewage farms.

(3) Sewage farms in India can be laid out at small cost, a maistry with a gang of coolies being able to do the grading of the beds and make the bunds and channels.

(4) Owing to growth being continuous more crops can be raised in India than in Europe and sewage can be more satisfactorily disposed of in very large quantities throughout the year.

(5) Owing to the temperature of the soil being particularly favorable to nitrification and growth in the presence of sufficient water the crops are very heavy.

(6) Owing to the scarcity of good forage during a great part of the year there is usually a good market for grass and hay.

(7) Owing to the exclusion of diseased cattle from the farms the grass is not liable to infection with disease germs. The hay compares favorably as a food stuff with forage from other sources.

(8) Sewage-farming can be carried on in the proximity of houses without affecting the health of the residents, though it is better to locate the farms at a distance from a town as there may be some nuisance from the sewage wells and main carriers owing to the decomposition of the sewage before it reaches the farms.

(9) Owing to porosity of the ground and the enormous volumes of water given off by evaporation and transpiration, under-draining is not generally necessary though it may be in particular cases.

(10) Sewage after passing through the ground is sufficiently purified to be admitted into a river, or to join the sub-soil water without causing pollution.

(11) The native cultivator is quite capable of laying out farms and carrying on sewage cultivation without close European supervision. He is an adept at irrigation processes, having inherited his aptitude and familiarized himself with the methods almost from the time of his birth.

(12) The system is suitable to parts of India where the ground is permeable and the rainfall is not excessive. It can be carried on profitably even where the flatness of the land necessitates the use of pumps, and should yield a much higher profit where the natural slope of the land permits them to be dispensed with.

No. 25.

Referred to the Sanitary Board for remarks.

(By order.)

Fort St. George,
11*th December* 1894.

(Signed) W. FRANCIS,
Acting Assistant Secretary.

To the Sany Board

No 25.

Referred to the Sanitary Board for remarks.

(By order)

W Francis

Dy. S. 2
15-12-95

Ag. Asst. Secretary.

Fort St. George
12th January 1895

To

The Sanitary Board.

No 25 Paid
Reference to the Sanry Bd for Remarks
(By order)
W Francis
Ag Asst Secy
11-1-95

20 The Sanry Bd

No. 478/S.

OFFICE OF SANITARY COMMISSIONER,
Camp Trupati
~~Fort St. George~~, 10th March 1895.

From

SURGEON LIEUT.-COL. W. G. KING, M.B., C.M., D.P.H.,
Ag. SANITARY COMMISSIONER FOR MADRAS,

To

THE Secy (Genl: Sanitation Deptt)
Sanitary Board

Chief Secretary
to Government
Local and Municipal Dept

Enclosure.

Govt Inms.?

SIR,

With reference to G.O. dated 12th January 1895, No 25, Local and municipal, I have the honor to forward herewith my remarks on Dr. Auld Cook's paper on Sewage Farming in Madras.

I have the honor to be
Sir
Your most obed Servt

W G King
Surgn: Lieut Col.
Ag: Sanitary Commissioner
Secy (Genl: Sanitation Deptt)
Sanitary Board

Local & Municipal Dept
CURRENT No. 878/95

Ent: 255/95
1651 dt 7-11-94
2189-90 & 226-w-94.
177-78 dt 11-2-93.
1620 dt 19-9-91.

Local & Municipal Department.

From W.G Kuig
Surgeon Lieut.-Col. ~~I. A. LAING~~,
Sanitary Commissioner for Madras,

To
The Chief Secretary to Govt
Local & Municipal Dept.
Fort St. George

No. 472
S.

Dated 10th
Despatched 11th March 189 5.
Received

Enclosures Five 5

Subject.

Submits remarks on Dr. Neild Cook's paper on Sewage farming in the town of Madras

Should be taken up
Should be tenanting
the flow of any sewage
into the Crown should
be conducted underground
so as the result upon
the

The Council is satisfied
that under
during sewage farms
is unnecessary. Of course
if the scheme referred to
in para 2 of letter is carried
out it will undoubtedly
necessitate
the result that
under sewage farms
are abandoned.
Legislation necessary
to give powers to
to intercept
Whatever course
followed, the large farm
north of Black Town
will remain, and Govt.
is of opinion that may
part should
this and discharge
resulting effluent into
the sea should be
taken.

No. 1.



No 2.



No 3.



Note. It is not necessary that these photos. should be re-produced for publication unless desired by Govt.

H.G.M



No 3.



No 2.



No. 1.

Done 30/4

Encl 2 to 1582/35



No. 4.



No. 5

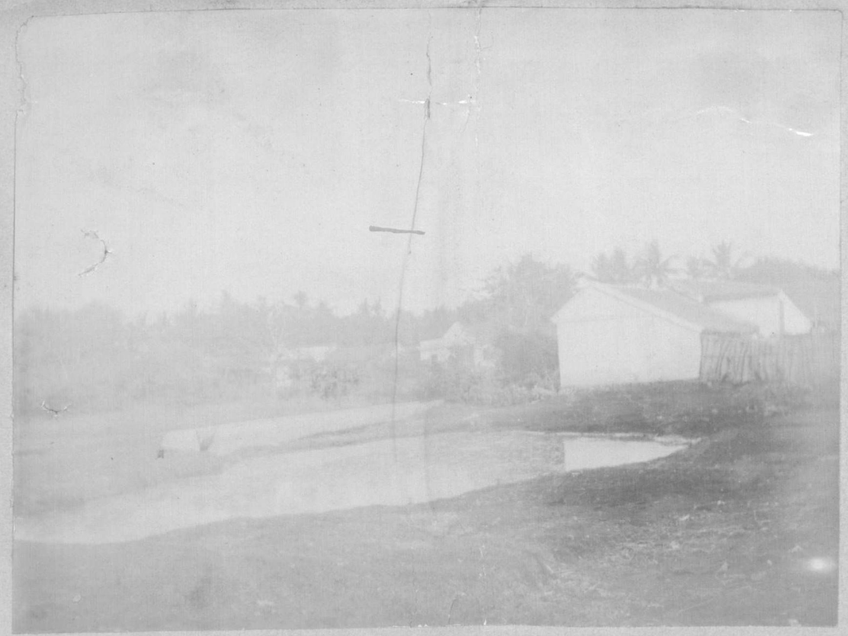
Vide Note W.E.K.



No. 6.

PW 5 6
1582/35

Vide Note W.E.K.



No 10.



No 11.

PW 2. 5
1582/35



No. 7.



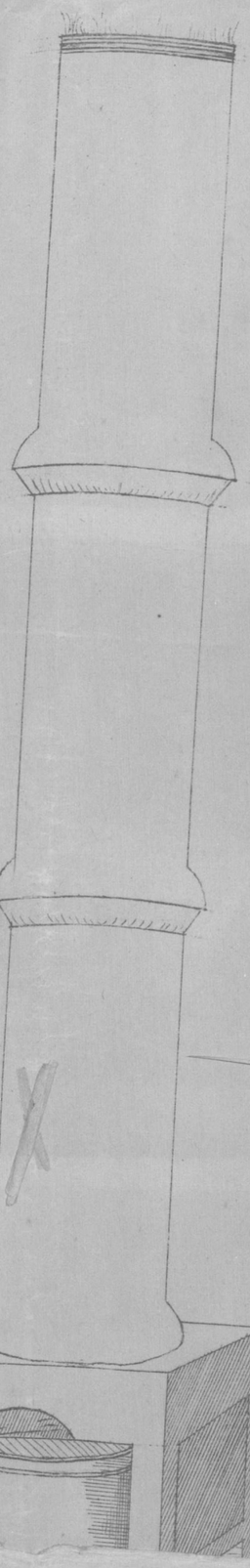
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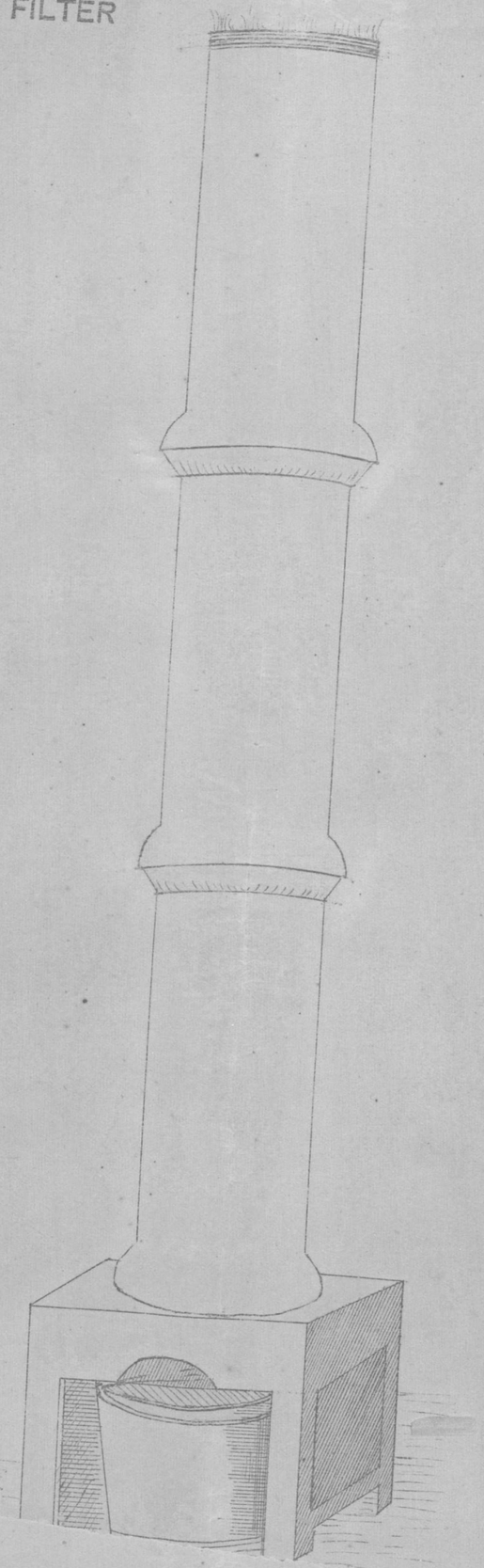
See Note M.B.K.

SEWAGE FILTER



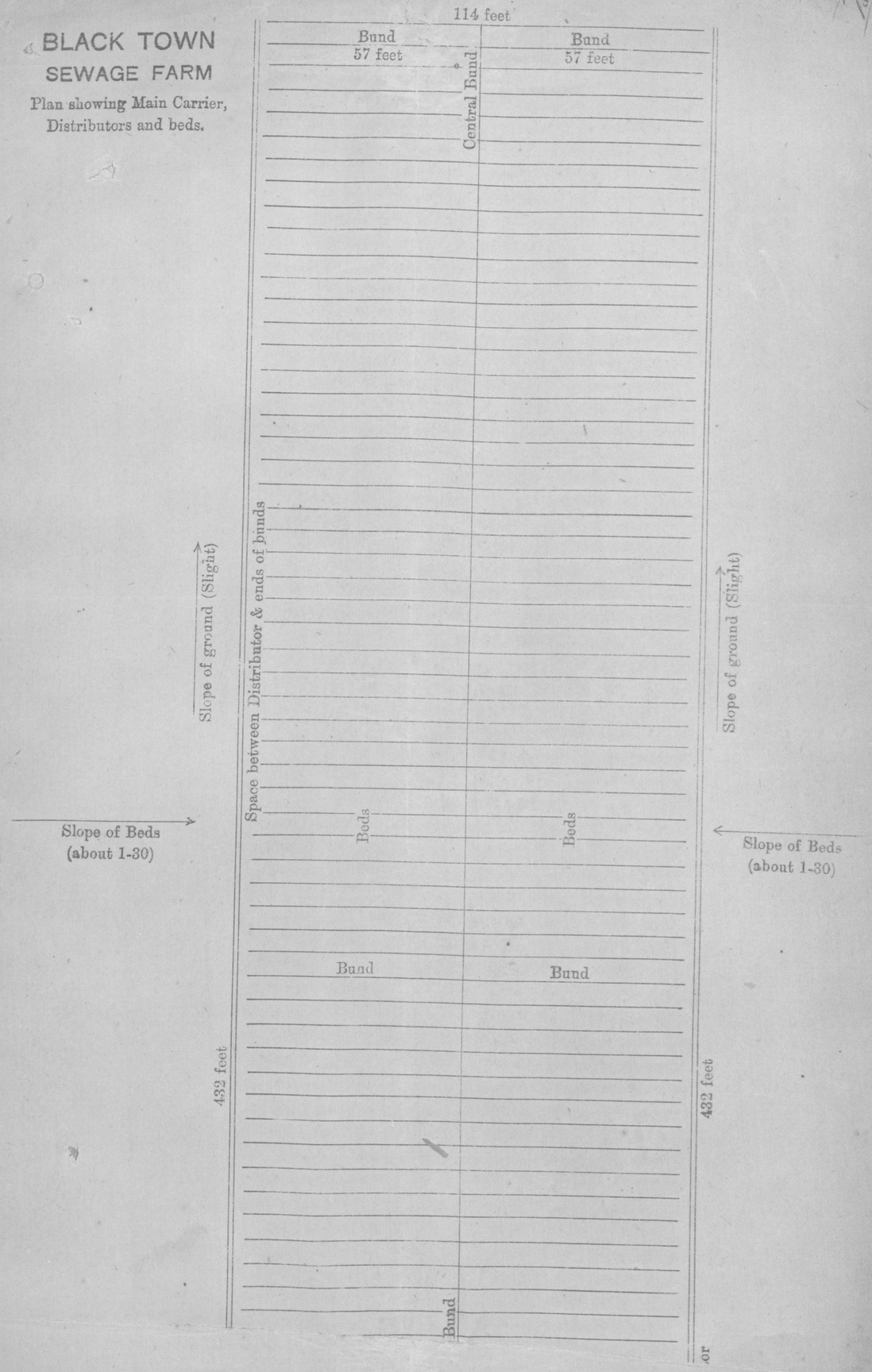
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SEWAGE FILTER



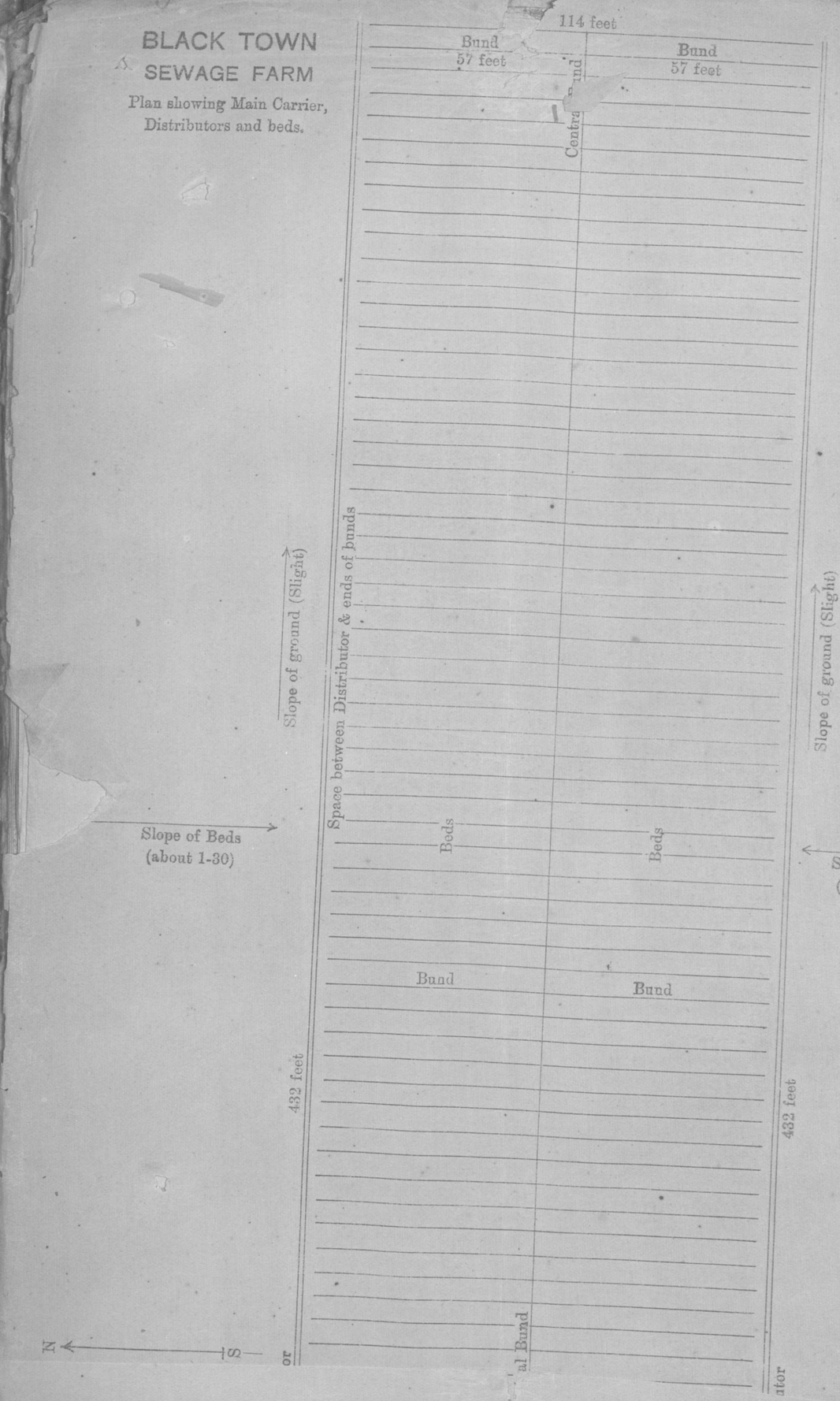
BLACK TOWN
SEWAGE FARM

Plan showing Main Carrier, Distributors and beds.



BLACK TOWN
SEWAGE FARM

Plan showing Main Carrier, Distributors and beds.



LOCAL AND MUNICIPAL DEPARTMENT.

Current No. 3051 M

From the President, Municipal Commission, Madras.

FOR ORDERS.

In para 61 of the Sanitary Comm^rs Annual Report for last year he said that the Sewage farm at Black Town was sanitarily defective inasmuch as there were no arrangements for underdraining the discharge of effluent, the practice of the disposal of sewage by soakage and discharge into the Cauum in the neighbourhood was permitted.

The Govt. of India noticed this in its letter in G.O. 2189. 2190-1 26.10.96 asked that the defects referred to might if possible be removed. (para 7 of the letter).

The Madras Comm^rs were asked in the same G.O. that

they proposed to do, & the result
is a paper on the sewage farm
by the Health Officer of Madras in
which they it is described as
working particularly well, and a
letter from him in which he directly
challenges all Dr. King's criticisms,
& says that under drainage is
unnecessary; that discharge of
the effluent is every where unnecessary
as it is perfectly harmless, & in
some of the farms it is impracticable on
account of the levels; & that there
is no disposal by soakage unless
it may be by occasional faulty
drains; & that the flow into the Cooum is
already being stopped. —
The doctors thus disagree as to
whether the defects that the
Govt. of India ask to be removed
really exist or not, & it is for
consideration whether the Com-
missioners are to be forced to
go in for under drainage & ex-
pensive systems for the disposal
of the effluent when their Health
Officer says these are not necessary.
The Health officer's arguments
showing that they are unnecessary
seem as far as may be judged
by a layman, to be strong.

There does not seem to be
any third party who is sufficient
by an expert in the matter to
be qualified to judge between
Dr. King, who is seldom satisfied
with any sanitary arrangement
that he finds in force, & Dr.
Neild Cook, who may not un-
naturally be some what biassed
in favour of his own farm.

It was proposed to refer the
papers to the Sanitary Board, but
Dr. King would almost certainly
do the drafting of the reply, as
the other two members know
less than he does upon the
matter & it might be that
the result be in any better position
to judge of the matter.

Dr. King however has not as yet
advanced any reasons at all
for his opinions that the farms
are sanitarily imperfect, & were
they received in detail Govt. might
be in a position to weigh his
remarks against Dr. Neild Cook's

the judge between them.. The papers may therefore, if it is submitted, be sent to the Sanitary Board for remarks.

W. 8.1.95 Lyon-

DW 9/1.
10/1/95

Sewage farming in Madras - Mt.

3051 In

FOR ORDERS.

Ref^ce 26th 12-1-95

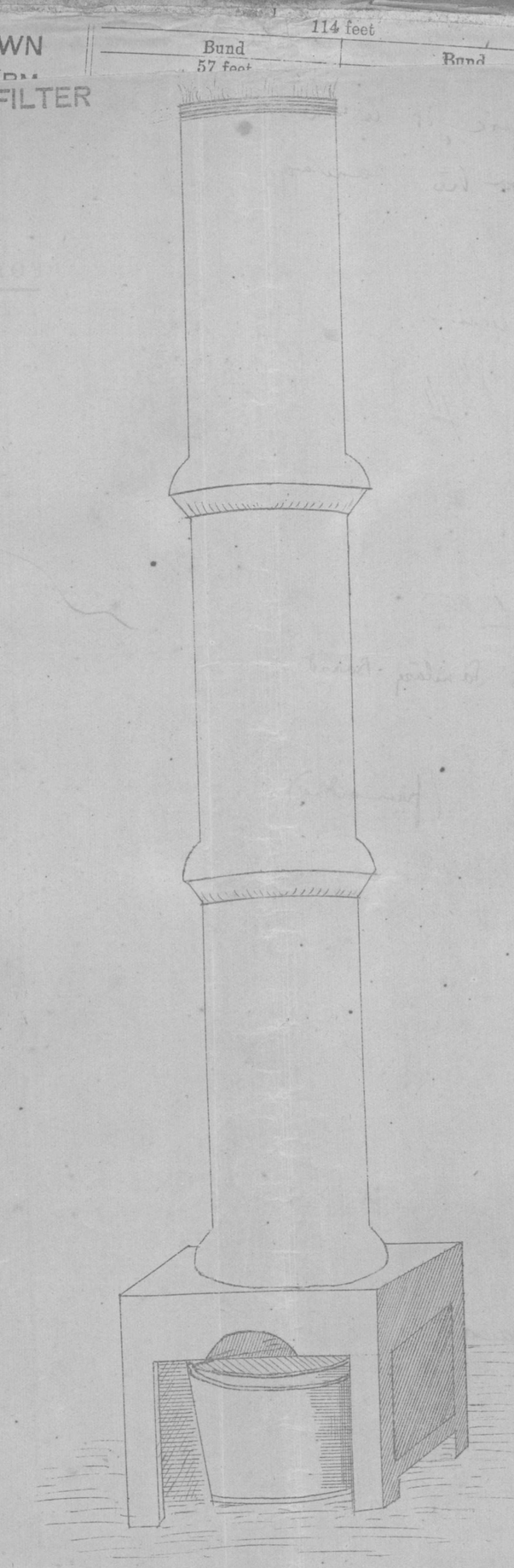
Referred to the Sanitary Board for remarks.

W. 11.1.95 (By order)

copy accepted
11/1/95

To, The Sanitary Board.
Dated 12/1

BLACK TOWN
SEWAGE FARM
SEWAGE FILTER



Reg: No. 1343—Copies

Litho. Survey Office, Madras.
1895

Current N°- 3051 M. L.M.

Corr.t No. 878 M.

DEPARTMENT.

From

Dated

189 .

FOR ORDERS.

Please see the notes and orders on Current N°- 3051, which contains the Municipal Health Officer's reply to Dr. King's statement that the Madras Sewage Farms are sanitarily imperfect inasmuch as they comprised no arrangements for under draining & the discharge of the effluent, & as the practice of disposal by soakage in the neighbourhood and discharge into the Cooum were permitted. This was sent to Dr. King in order that he might explain his criticisms in detail, & the current for disposal is his reply.

The first five pages of this are mostly occupied with an answer to certain passages in Dr. Cook's Medical Congress paper on the Sewage farms at Madras, which are irrelevant to the present discussion, but the letter is not well-arranged, & it is necessary to read the whole of it.

The statement of the grounds for his assertion that underdrainage & the discharge of the effluent are necessary, & that disposal by soakage in the neighbourhood & by discharge into the Cooum occur is given by Dr. King in pages six et seq.

Dr. Cook (vide current 3051-M.) said that underdrainage was "unnecessary as the ground is perfectly permeable and the purified sewage will not cause pollution, & the discharge of the effluent from the proposed drains is impracticable in the case of some of the farms on account of their

Dwg 3
1562/55

evils.

Dr. King maintains that underdrainage is certainly necessary as otherwise the porosity of the soil would quickly diminish, & it would be less capable than before of properly nitrifying the sewage, moreover oxygen would enter drained soil more quickly. As to the purified sewage not causing pollution Dr. King denies this altogether. He says it causes considerable pollution that there is "notorious evidence of this, & that in Paris as a rule exists that when the discharge of the effluent is interrupted by the rise of the Seine the crude sewage is to be discharged into the river direct rather than that the subsoil should be poisoned by it being heated back into the drains & diverted into the subsoil. Moreover subsoils have faults & fissures, & so it might well be (and actually was in one recorded case) that poisonous effluent might travel in an imperfectly nitrified condition for a great distance under-ground.

He suggests that the deterioration of the Seven Wells water, the typhoid that broke out among the troops when the subsoil water level fell, & the fact that Cholera is very frequent in the places in line with the subsoil water flows from the Sewage farms are due to the absence of underdrainage.

He quotes from a report of Mr. Standish Lee in 1872 showing that under-draining part of Dr Mellows' Road farm did that part a great deal of good.

As to the impracticability of the draining Dr. King asserts that as Dr Mellow's farm is partly underdrained it might be drained throughout, that the field in Photo. No. 6 might be drained, as might also "certain of" the plots along the Banks of the Cooam and Cochrane's Canal. — These are very small proportions of the whole of the Farms & it would appear that the Health officer's statement that the levels won't permit underdraining in many cases must be correct. Otherwise Dr. King would have gone into the matter at greater length, instead of giving it only the six lines it receives on page 7.

As to the disposal by soakage in the neighbourhood, Dr. King Cook said that no such soakage occurred except through faulty pipes. Dr. King however sends photos showing (No. 3) that the sewage is in one case actually pumped by Municipal Pickotas onto a piece of ground where it is allowed to soak through the soil; that overflows from a sewage pit is lead by a pipe in another case (photo No. 7) to a plot of land where it is left to stand; & that the leadings from the sluice-gates of one of the conduits ~~soaks~~ stagnate in another place (photo. No. 10). Photos 4–8 show other cases of disposal by soakage.

It would seem that Dr. King has made this point.

As to discharge into the Cooum, Dr. Cook admits that it occurs, and

that the discharge is small, & only occurs from some of the smaller farms at night (when the amount of sewage running is much less than at other times) when the pickotahs cannot well be worked, & that storage tanks for the surplus are to be provided to keep it out of the Cooum until pumping begins.

2. It is submitted that now that Mr. Cousins' schemes of drainage have been abandoned it is necessary that every possible improvement in the existing system should be carried out as far as funds permit. It is submitted therefore that the Commrs. may be told that their farms do not appear to be above reproach, & that underdraining should be estimated for where practicable, & that the disposal by soakage should be immediately stopped & that proposals for preventing every bit of the discharge into the Cooum should be drawn up & estimates for & sent to Govt. If these estimates are not then altogether too high the Commissioners may be definitely told to carry them out.

WC 20.3.95

The reproduction of Mr. Lings photos for publication (with the report) does not seem necessary. They clearly & particularly clear in showing what they are meant to show.

WC 20.3.95

Defects in Madras Sewage Farms. —

HM

(for orders).

Certainly not necessary

HS

[G/25]
500—26-6-94.

DEPARTMENT.

C. No.

FOR ORDERS.

I have been through these papers. It seems of no use continuing the discussion and the only thing apparently to be done is what the A.G. suggests. It would be desirable perhaps for the Commrs to consider the subject of closing the worst sewage farms but notably this cannot be done until some alteration is made in the present system of drainage.

HS
3/4/95

I have no doubt that Dr. K. is generally right

HS

Since writing the note above I have heard from Mr. Ellis that a Committee of the Municipal Commissioners which has been sitting in accordance with the instructions in GO. 1651. M. 7.11.94 on Mr. Cousins' schemes to consider what can best be done to improve the existing drains are inclined to favour a proposal of Mr. Ellis' to introduce at a comparatively limited cost the backbone drains of Mr. Cousins' scheme, (without going to the expense of the smaller drains & house connections) which should be constructed of such a size that they would carry off any sewage that is ever likely to be required to be dealt with, (of the size, in fact, that Mr. Cousins' contemplated)

Both Mr. Ellis & Col. Moore have spoken to me as to this.

I think the papers may as well go to the Commrs, & be postponed. No doubt, if this modification of Mr. Cousins' scheme is carried out (and from what Col. Ks. told me it appears to be both feasible & within the means of the Commrs), all the small farms which are scattered about the sewage place will be got rid of,

be led from the more closely populated parts of the town so as to tap the existing & at present disconnected series of open drains which lead into the various sewage farms in the middle of inhabited areas to which Dr. King so strongly objects. By utilizing the present open drains it is thought that a large saving on Conservancy scheme could be effected, while by preserving the size of the main drains suggested by him the backbone of any future more elaborate scheme could be laid down, & additions could at any time be made upon one uniform system should funds become from time to time available. The sewage collected in these main drains could be pumped either to an extension of the existing Black Town Farm or to the large areas of waste ground north of the People's Park. By affording a greater fall than any open drains can give in a place as flat as Madras, this system would at once keep those parts which are served by open drains in a less horrible condition than they now are, but would enable the Comm^rs to gradually in a short time close every one of the small sewage farms which are now dotted all about Madras.

If this scheme is ever sanctioned the whole aspect of the present problem will be changed, & it will be unnecessary to improve the sewage farms, as no more sewage will be placed upon them.

I have recently been over most of the farms in Madras, & it is easy to see that Dr. King's suggestions would cost a considerable sum to carry out. That this sum would be well spent were the farms to remain where they are

Defects in Madras

Sewage farms

But the big farm N. of Black Town will remain & should be properly treated, i.e. shd be underdrained & the resulting effluent discharged into the sea —

HD
18/4/95

HW

L. & M.

DEPARTMENT.

From

Dated 189 .

FOR ORDERS.

indefinitely is perhaps certain, but if there is a chance of their being removed within a reasonable time it would seem inexpedient to ask the Comm^rs to at once expend it.

It is regretted that these facts were not known before the first note was written, so that the necessity of returning the papers might have been obviated.

It seems clear to the ordinary layman going round the Madras sewage farms that any proposals for getting right on of the town the masses of filth with which they deal in such a thorough manner are preferable to tinkering the methods of disposal of it to which they are now forced, & improvement is called for on a comprehensive scale.

It is submitted therefore that these papers may lie over until Committees & the Commissioners reports on the scheme referred to received.

WH 4.4.95

HH
18/4/95

Madras Sewage

Farms.

818m
10.5.95

O.

878m

H.M.

(for orders).

C.S.

draft order for approval.

Order

The memorandum of the Sanitary Commissioner will be forwarded to the Municipal Commissioner for consideration and report.

2. The Government cannot admit that underdraining is unnecessary but ~~4 of Paris~~ that wherever practicable it should be carried out. The Commissioners will be requested to submit estimates for carrying it out as per as possible with a report as to what funds are available for the work.

3. Proposals for prevention of the discharge into the Cooum should also be submitted with estimates and the system of disposal by sewage should be put a stop to as soon.

(from orders)

President
Municipal Commission
Madras.

17/4

1895

4 Mar

Remarks by the Acting Sanitary Commissioner for Madras as to Madras Sewage Farming.

Most of the matters dealt with in Dr. Cook's Medical Congress paper have been long established, and I therefore would confine attention to such unusual conclusions as I think require modification. Dr. Cook states, "owing to the exclusion from the farm of diseased cattle, the grass *is not liable* [italics mine] to infection with disease germs." Because a place is styled a sewage farm and even cattle be excluded, it does not follow that infection will not occur. This is ~~simply~~ solely a question as to what chances the sewage used had of infection and of getting rid of it before arrival at the farm. The instance given in support of this contention at page 5 of Dr. Cook's paper, simply points to the possibility of well-dried hay being a safer forage where anthrax is concerned than grass, the reason being that prolonged exposure to sunlight is inimical to anthrax spores, whilst damp grass and ill-drained soil offer conditions favourable to their vitality. Against this, however, must be placed the experience that hay by its mechanical action is by good authorities held to be likely to favour infection by the making of abrasions in the mouths of animals. In the case of a sewage farm devoid of under-drainage and subject to waterlogging as in the case of DeMellow's, anthrax spores introduced with the sewage would be in little better position than in the damp soil surrounding many of our villages. But there is this to be said; in town life anthrax blood ought very rarely to reach the drains, the animal being usually taken out entire from the neighbourhood of habitations; whereas, in the country, the cutting up of animals is practised by chucklers where the animal drops, and by this process the spores, as contrasted with the bacilli, are set free. Of course, I do not forget the claims of certain authorities that pathogenic microbic life suffers in sewage farms as a result of crowding out by saprophytic germs and alkalinity of the sewage; but, on the other hand, I cannot so far forget the highly-resistant character of the anthrax spores, and the variable factors that have to be dealt with in connection with sewage farming, as not to consider Dr. Cook's assumption that sewage farms are "not liable" to infection as dogmatic, and likely to lead to serious neglect of requisite precautions.

Again, he affirms that "sewage farming can be carried on in the proximity of houses without affecting the health of the residents, though it is better to locate the farms at a distance from the town as there may be some nuisance from the sewage wells and main carriers owing to decomposition of the sewage before it reaches the farms." To assign as the sole reason for removing sewage farms from inhabited areas that "some" nuisance may result from the main carriers is to say the least regarding a serious sanitary question lightly.

Dr. Cook quotes, as supporting his contention as to innocuousness, Dr. Carpenter's conclusions as to the Croydon farm. That enthusiast would have had us believe that either the grass seized disease germs, or that they committed suicide by entering into the grass! But here is what the Medical officer (Dr. Creasy) of the Orphan Asylum, mentioned by Dr. Cook as being in the neighbourhood of the farm, reports on the subject—"typhoid fever has been in every cottage on the estate." The Medical officer of Health, Croydon, also some time back persisted, in spite of Dr. Carpenter's opinion, in regarding the presence of the farm as influencing the propagation of scarlet fever in the vicinity. Again, we have the classical instance of the Cumberland and Westmoreland Lunatic Asylum, where dysentery was traced to mismanagement of the sewage farm. Pasteur's recent protest against sewage farming in the vicinity of Paris also cannot be ignored. The evidence produced by Dr. Cook as to the

innocuousness of the Madras sewage farms is unfortunately of little utility. Such a matter cannot be approached without correctly-worked out statistics; loose statements can be of no value in deciding so important a question. That he might have difficulty in a town having a mortality of over 40 per mille in finding that the localities of sewage farms are specially affected with certain diseases I can well imagine, the condition of the sub-soil of Madras generally being that of a badly-managed sewage farm; but to deduce statements as to safety, applicable to India generally, from observations made in so insanitary an area as the Madras Municipality would demand a very close study of refinements in vital statistics.

His conclusion that, "owing to porosity of the ground and the enormous volumes of water given off by evaporation and transpiration, under-draining is not generally necessary, though it may be in particular cases," seems to me to exhibit confusion of ideas as to the functions expected of under-drainage. It stands to reason that the greater the rate of evaporation the quicker will porosity diminish simply from rapidity of deposit of sludge on the soil surface; porosity being diminished, the greater would be the urgency for under-drainage in reference to nitrification.

Another conclusion of Dr. Cook's is as follows:—"Sewage after passing through the ground is sufficiently purified to be admitted into a river, or to join the sub-soil water without causing pollution." This is a most dangerous generalization. Of investigations as to the influence of filtration of sewage through soil, there is endless evidence from the time of the Rivers Pollution Commission downwards. No more complete testimony can possibly be quoted than that obtained through a series of years, aided by all the resources of modern science, than the investigations of the Massachusetts Sanitary Board. Their chemical and biological examination of filtrates of sewage, under every conceivable condition, amount to many thousands. The utmost any expert on this subject has hitherto ventured to affirm, nevertheless, in view of this mass of evidence, is that as a result of filtration through soil there is secured one of the best practicable methods of purifying sewage; but no one has yet been found who would assert that in the filtrate joining either sub-soil or rivers "pollution"—in whatever sense that term open to most varied interpretation, is applied—does not occur, or, that its freedom from disease-bearing agents is so absolute as to warrant its being stated that it is incapable of "in any way endangering the public health."

That many important towns in civilized countries are obliged to get rid of their effluent into rivers is a matter of necessity, and is accomplished with the knowledge that dilution and the various processes of self-purification will further aid in the work of prevention of danger, already attempted by filtration through soil. The same reasoning applies to the admission of such filtrate to the subsoil water; no one would however deny that danger exists. Thus, on the Paris sewage farms, rather than run the risk of contamination of the sub-soil, it is ruled that when the effluent from the under-drains is interrupted by rise of the Seine, the crude sewage must be discharged into the river.

Dr. Cook has gone to the trouble of making three special experiments with soils from the local sewage farms. He shows that he produced a filtrate that was equalled in evil composition with that of certain waters in Black Town, and he argues therefrom that no untoward result will occur, by sewage that has passed through a sewage farm entering the sub-soil. This, of course, proves nothing; as no one would wish to affirm that the sewage sodden soil of Madras is likely to produce good water in other than unusual localities. But, to argue from such data to a general application elsewhere, is quite another matter. In the first place, in localities other than Madras such an effluent would seriously pollute the sub-soil considered merely from its chemical composition; but Dr. Cook's experiment ignores the factor upon which any evidence as to disease production must be based. Although a certain unwonted proportion of albumenoid ammonia and chlorine would certainly not improve a human being's chances against disease, the risk cannot be gauged by this, but by the presence or absence of the causative agents—that is, of specific microbes. On this important point Dr. Cook's results afford no information; the experiments of the Massachusetts Board, however, supply the deficiency. It is shown that sewage filters working under the most favourable conditions can deprive sewage passing

through them of 99 per cent. of micro-organisms. But seeing that each cubic centimetre, or, say, each half-teaspoonful, may contain 1,000,000 microbes originally, the chances of specific disease germs reaching sub-soil water in the vicinity of a sewage farm can hardly be ignored; especially if this addition to the soil proceeds year after year, and there be no under-drainage to assist nitrification and to remove the effluent to the further self-purifying processes of water-courses and sunlight. But whilst this is the best result procurable, it must be remembered that 95 per cent. is in certain conditions found to be all that can be accomplished, and that errors of management reduce this enormously. When, therefore, Dr. Cook points to his three experiments as proving the safety of sub-soil water from pollution, his conclusions can hardly be said to be complete, irrespective of the circumstance that the factor of prolonged use of the filter has not been entered into. Moreover—probably unconsciously—he has in this experiment not faithfully imitated the processes which proceed on Madras sewage farms; his filter represented a farm *with* under-drainage, which he has decried as unnecessary.

His deductions from these experiments that "made soil" is rich in nitrifying organisms is universally acknowledged, but I cannot help thinking his advice to imitate its efficacy by using *two feet* of "sweepings" over sand goes beyond solid facts. If there be a large amount of nitrifying microbes in such a mixture, so also have they a large amount of organic matter to get rid of without its being added to by sewage being forced upon it. In short, with two feet of ordinary Madras town sweepings above a layer of sand, the latter would find its work of purification pretty well cut out for it in disposing of the filth—including fœcal matter—brought from this source alone. Instead of thus trammelling biological action, experiments show that by permitting the entrance of oxygen within the soil voids by quickly depriving it of excess of moisture, air finds entrance and *thus nitrification can be best supported*—an effect that can be brought about by under-drainage. Dr. Cook's further inference that if he had possessed a filter with earth more compact * as in the case of soil of the farms that had been long used he would have secured better results chemically, is also not in accordance with actual testing of such comparative conditions nor with the theory of nitrification just alluded to.

When, however, applying experimental results to practice, it is hardly necessary for me to say that the sub-soil of towns does not always fulfil the condition of a neatly-constructed filter, such as depicted in Dr. Cook's diagram. There are few sub-soils that have not faults, varying levels, and crevices that would guide, or permit to pass, sewage before it has undergone purification. Thus, places distant from the point of deposit may by sub-soil soakage be contaminated with sewage, and every year that a patch of soil receives filth and is taxed to purify it, there is ample proof that the greater liability is there for sub-soil pollution. Once a pathogenic microbe has successfully run the gauntlet of the upper 18 inches of soil teeming with saprophytes, the chances of being carried forward with the sub-soil water, and being aided in multiplication by the presence of nitrates from the sewage filtrate, are favourable. The classical instance of the Lausen typhoid epidemic showed that by irrigation of the soil surface, the typhoid bacillus can be sent through *a mile of sub-soil*.

In consideration of the fact that sewage reaches the soil of Black Town from other sources, I by no means wish to lay the blame solely to sewage farming, or solely to the fearful mass of diluted sewage collected in the Versarpady tank—*vide* Photograph No. 11—that escapes treatment on farms between Pursewalkum and Cochrane's Canal, but it is indubitable that within the last few years the "Seven Wells" water has deteriorated in quality. Further, coincidently with a fall of the sub-soil water—though not proved necessarily to be depending on this cause—typhoid fever increased amongst British troops using it to a lamentable extent. These wells are in a line with the sub-soil water flow from the points of pollution named. Whether or not the troops obtained the specific disease of typhoid from these waters, the progressive defilement

* To prove that the process of purification did not depend upon the compactness of the pores though which sewage was passed, the Massachusetts Board used gravel stones of the size of beans, which were previously washed free of all sand. The Board concluded that "the removal of this organic matter is in no sense a mechanical one of holding back material between the stones, for they are as clean as they were a year ago; but it is a chemical change, aided by bacteria".—W.G.K.

which the wells have undergone, as proved by chemical analysis, shows that allowing sewage to pass through earth, whether the site be called a sewage farm or a street, matters little, and that, as time advances, if the filter be overtaxed, pollution of the sub-soil water results. Indeed, I should think that the mere *possibility* of defective filtration through the surface soil permitting pathogenic germs to pass, should forbid sewage farms being placed in a position in which they could add *in any degree* to the impurities of the sub-soil of an inhabited area. I would point to the fact that if the Health Officer's spot-map of the epidemic of cholera of 1892 be examined, it will be found that there was decided preference for the disease to flourish in those parts of Black Town within the sub-soil flow of the insanitary areas I have alluded to. I noticed this tendency of the disease in my investigation of the epidemic of 1882 (*vide* my Report thereon) and regarded preference of the disease for the parts near the sea coast as due to the increasing increments of filth brought by the sub-soil flow thither proving an auxiliary cause of propagation in the presence of the cholera microbe.

In this connection, it is well to remember that certain of the Madras sewage farms are formed, as Dr. Nield Cook would advise, of town rubbish; that is to say, in the special case of Madras, of a very large amount of fœcal matter *plus* rubbish. This process is shown in Photograph 9. In this instance, the dumping has been effected so as to build in the walls of native huts! Possibly, the Health Officer trusted to the powers of ten inches or so of mud wall between the coolies and this filth, to protect them from disease germs. But, granted public bodies made, as they should, their farms of clean material, if necessity compelled their use within the water-shed or sub-soil flow of inhabited areas, I need hardly point to the danger of their being informed that it is safe for a population depending on well-water to so risk its contamination. In this connection, it must be remembered that few of our towns are yet provided with public water-supply systems. To argue that in the absence of a correct sewerage system, disposal of sewage on farms within inhabited areas on sites as completely out of the direction of the sub-soil flow through the town as feasible is justifiable, is the utmost that can be said; but to attempt from faulty data at disposal in the town of Madras to teach the people of India that to retain sewage farms in the midst of inhabited areas is neither to risk health nor the purity of well water, is subversive of the ordinary principles of hygiene.

It would have rendered me more capable of understanding the "strong opinions" I am supposed to have "inferentially" stated, had the Health Officer taken the trouble to speak of sewage farms within inhabited areas and those without. To the former, my remarks as to absence of under-drainage are obviously applicable. As to proposing under-drainage at the time of writing, I had no such intention; I simply described the condition of these farms with reference to sanitary results on their surroundings as aggravated by there being no under-drains. When my Annual Report was written, I had every reason to hope that Government would adopt the recommendation of the Water-Supply and Drainage Committee of 1890 (of which I was a member), and would abolish all farms within inhabited areas—a recommendation Dr. Nield Cook would now seem to coincide with, although it seems to me a surprising position to be assumed in view of his declaration of their innocuousness. But, in view of the change of intention of Government as to carrying out Mr. Cousins' sewerage scheme, of which I have been since informed, the question of the advisability of correcting the evil conditions that have been allowed to exist on the farms in inhabited areas ought certainly to be considered. Where I think this action desirable, I will state further on.

Dr. Cook attempts to be-little the effects of under-drainage in a manner that ought to have no influence upon his readers. After stating that under-draining had been employed in a portion of the DeMellow's farm, he gives it as his opinion that "the drain pipes in this case were of little or no use, as they were placed below the level of the sub-soil water and had no outlet."

Now, it seems to me most unlikely that an engineer would have laid down sub-soil drains without an outlet, whilst, even if this were so, the drains would not have been without a certain amount of influence in facilitating air change and water subsidence.

At any rate, here is Mr. Lee's statement of the results, which I extract from a very interesting report written on sewage farming in Madras by that officer in 1872: —

> "This gave the key to our action. That part of the farm where we could get absolutely nothing to grow was, on Mr. Robertson's recommendation, immediately broken up to a depth of 18 inches and drained every six feet with pipes four feet under the ground level. With marvellous rapidity we obtained an excellent crop of grass. This advance has been maintained, and these beds are now one of the most productive portions of the farm. The supply of pipes running short, many of the beds were drained less thoroughly by a layer of loose brickbats about six inches in depth placed at the bottom of the drain-cutting and then covered in. In others a thin earthen tile was placed at the bottom and the loose brickbats placed upon that. The closeness of the drains made up for their imperfection and that portion of the farm is now almost too well drained, since the sewage runs through so freely that a large flow is necessary to ensure that the lower end of the bed shall be irrigated. Such careful and thorough drainage is costly and requires much time. There has been neither means nor opportunity for covering the whole farm with such a net-work, though it is hoped that in the course of time, the whole may be provided with drains fifteen feet apart and four feet deep."

Surely, the statements of the officers concerned at that time who saw the results, namely, Dr. Cornish, Mr. Lock and Mr. Standish Lee ought not to require to be balanced against the opinion given "inferentially" of the Health Officer of 26 years subsequently. Indeed, I am inclined to think that if the Health Officer searches for them, he will find the missing outlets.

As to the quantities which Dr. Cook says are disposed of on the Madras * farms, I think, unless he produces much better evidence than the statement that a contractor demanded more after receiving an amount twelve times greater than is required on ordinary farms, the estimate may well be open to doubt. Dr. Cook himself states that he has at times seen the sewage of the Black Town farm not being used, especially after heavy rain. It has been my fortune to see it also thus wasted, and I presume that at the Black Town farm, as in other farms of Madras, the contractors take care not to forget that their interest is the production of grass and that during certain stages of growth flooding is not desirable. That contractors should wish to deprive a rival of a supply of sewage is hardly a fact that can aid the conception of the amount really used. It is, in short, not enough that such and such an amount passes on to a farm; it is requisite that it be shown that a measured amount of sewage is taken up by a measured amount of land daily, from month to month and year to year, when worked on sewage farm principles, and that a correctly-purified effluent results.

In any case, the utility of teaching that soil should be taxed as to disposal is open to question. Experience everywhere shows that even in a sandy soil the capacity for filtering steadily diminishes as time advances, and hence the usual resort to under-drainage. The greater the amount of sewage per acre the less perfectly can purification be accomplished, and the greater the risk of sub-soil water contamination. But whether the soil used be of India or Great Britain, the sewage to be purified must bear a certain definite proportion to the voids in the soil, degree of concentration of sewage, and activity of nitrification. In the latter process only, therefore, is there likely to be any advantage in India that is not reaped elsewhere, in view of favorable temperature. But in making any estimate for general application, it must be held in mind that Madras sewage is not likely to be representative of that in towns where correct methods of removal are in force. Here, sewage passes in open drains of small velocity permitting of deposit at every interruption of a leaf or stone, and thus sludge, which should reach the farm with the water, is removed by hand into carts in the streets; and it must be understood that it is the disposal of this sludge on the soil

* 75,000 gallons per acre.—W. G. K.

not only with the object of removing effluent, but of accomplishing purification in the most complete manner reasonable and practicable. It seems to me that it is due to a failure to appreciate the full importance of using the best means available, that I am indebted to the Health Officer for his protest. The securing of circulation in the soil by under-drainage where purity of effluent is aimed at, especially on limited areas, is as essential as respiration to a human being, to which function the access of oxygen to the soil voids, enabling nitrification to be effected, has been aptly compared.

I see no reason whatsoever, from a perusal of Dr. Cook's Medical Congress paper, to modify my opinions that, whilst the Madras Municipality have so managed their farms as to prove them a financial success, these are worked on very bad sanitary principles; it being absurd to suppose that a sewage farm meets sanitary requirements unless it is capable of disposing with safety to the population *on its soil at all times* *all* sewage intended to be dealt with by it. Of what utility, except for economic purposes, can a sewage farm be which every seventh day refuses to purify its sewage, and pours it in a crude state into a stagnant pool that extends through the breadth of a thickly-inhabited city! In short, all that can be said as to their management is that farming with sewage is pursued — not *sewage farming* in the sense accepted by sanitarians.

6th Feb 1895

W. H. King. D.P.H.
Surg. Lt. Col.
Ag. Sanitary Commissioner
for Madras.
Secretary (General Sanitation Dept.)
Sanitary Board.

Lr 818 to 819 95

1-2 Slandard

3 Agenda

4 Standard

5-6 Agenda

Ogs.1
1562/55

58

Order dt 10-5-95 re 818 Lr

The Memorandum of the Sanitary Commissioner will be forwarded to the President for consideration.

3. It is understood that a Committee of the Commission is now sitting to deal with the question of improving the existing system of drainage and that the main feature of the recommendations which it will make will be the introduction of the back-bone drains of Mr. Cousin's scheme without, for the present, the subsidiary drains and house connections. If this plan is introduced it will probably be possible to get rid of the small sewage farms which are scattered about the town and to concentrate all sewage farming on one spot.

3. But in the meantime measures to effectually stop the soakage to which Dr. King alludes should be taken and proposals for preventing the flow of any sewage into the Cooum should be considered and estimated for and the result reported to Government.

4. His Excellency in Council is not prepared to admit that underdraining of sewage farms is unnecessary. Of course if

if the scheme referred to in paragraph 2 supra is carried out with the result that the smaller sewage farms are abandoned it will not be necessary to go to any large expense in underdraining these, though, as it will be some time before any improvement in the existing drainage system can be executed it would be advisable wherever under-drainage is manifestly necessary to carry it out at once as economically as possible, soakage being in all cases promptly dealt with. Whatever course, however, is followed as regards the drainage of Madras the large farm North of Black Town will remain, and Government is of opinion that very early steps to under-drain this and discharge the resulting effluent into the sea should be taken.

JS 7/5/95

Secra
8.V.

To,
The President M. C. Madras
Sanitary Commissioner
Dated 20/5/95

GOVERNMENT OF MADRAS.

LOCAL AND MUNICIPAL DEPARTMENT.

READ – the following papers :—

From Lieutenant-Colonel G. M. J. MOORE, C.I.E., President, Municipal Commission, to the Chief Secretary to Government, dated Madras, 3rd December 1894, G. No. 495.

With reference to G.O., dated 26th October 1894, No. 2189 L., Local and Municipal, I have the honour to forward the accompanying letter from the Health Officer together with the paper referred to therein.

2. It is unnecessary for me to offer any remarks on what is purely a professional matter, except to say that the storage capacity of the wells will be increased, so that there may be no overflow of sewage at night.

ENCLOSURES.

From Dr. J. NIELD COOK, Health Officer, to the President, Madras Municipal Commission, dated Madras, 27th November 1894.

Concerning the comments on the Madras sewage farms contained in the annual report of the Sanitary Commissioner of Madras for 1893, referred for report in G.O., dated 26th October 1894, No. 2189 L., Local and Municipal, I have the honour to offer the following remarks.

2. In the few lines devoted to the subject the Sanitary Commissioner inferentially expresses very decided opinions. As I am unable to accept his conclusions and a mere expression of my opinion is not likely to weigh with Government against that of their own Sanitary adviser, I beg to submit a copy of a paper written for the Indian Medical Congress, in which I have dealt with the matter at some length (*vide* pages 6 & 7).

3. I consider that under-drainage is unnecessary, as the ground is perfectly permeable and the purified sewage will not cause pollution, and that the discharge of the effluent from the proposed drains is impracticable in the case of some of the farms on account of their levels. Discharge of sewage into the Cooum only occurs in the case of some of the smaller farms principally at night when the picottahs cannot well be worked. The amount is not large, as much less sewage flows at night than during the day. The Commissioners propose to deal with it by providing cisterns or storage tanks into which the sewage can flow until pumping is recommenced. The objection to this is that in a hot climate sewage rapidly decomposes, so that there is likely to be some nuisance from the stored sewage. I am unaware of any such thing as disposal by soakage in connection with the sewage farms. Any soakage which occurs is in consequence of faulty drains. If it were not for the presence of sewage farms in inhabited areas, disposal by discharge into the Cooum and by soakage would be the rule rather than the exception. With the introduction of a good system of sewerage capable of carrying all the sewage to the north of the town, the disposal of it could be arranged for by the extension of the Black Town farm and the difficulties now experienced would disappear.

Sewage Farming in Madras and the suitability of the system for India—By J. Nield Cook.

How to dispose of sewage has always been a problem of paramount importance. I do not propose to discuss the laws of Manu or Moses or matters of ancient history. For my present purpose sanitation may be said to have commenced in the latter half of the century. In 1857, the Royal Sewage Commissioners laid it down as an axiom that "the right way to dispose of town sewage is to apply it continuously to land." However, considerable difficulties were experienced in putting the principle into practice. The heavy soils found in most parts of England, the abundant rainfall throughout the greater part of the year, the low temperature during the winter months when vegetable life is practically at a standstill, and the difficulty and expense of acquiring suitable lands of sufficient extent in the natural direction of the drainage, have prevented the application of the sewage to the land becoming in any sense general. In 1875, the committee appointed by the Local Government Board to inquire into the various methods of sewage disposal reported "that land irrigation is not practicable in all cases." The object of this paper is to show that the adverse conditions which prevented the general adoption of this method of disposing of town sewage in England are for the most part absent in India. A trial extending over a quarter of a century has been made in Madras, where the local conditions are in no way exceptionally favorable, and has proved that an almost unlimited amount of sewage can be disposed of in this way in accordance with the best hygienic principles, and further that the produce of the farms finds a ready market and realizes a handsome profit on the outlay. At the same time I hope to give such practical details as will enable any one to make a more or less extended trial of the system with good prospects of success.

The idea of adopting land irrigation as the means of disposing of sewage in Madras was conceived by Mr. Standish Lee, the Municipal Engineer, in the year 1869. No worse site could have been found anywhere about Madras than that of the first experiment. This was in the neighbourhood of Chulay, and is now known as the D'Mellow's Road farm. It was a dismal swamp, periodically submerged by salt water, which on evaporation deposited a saline mud. The soil was black, plastic and as retentive as stiff clay. Not even a blade of grass grew there. Operations were commenced in June 1869. The swamp was reclaimed by depositing street sweepings and was planted with guinea grass. Some crops were obtained, but subsequently difficulties were encountered. With the advent of the hot weather of 1870 evaporation increased considerably, and salt was drawn to the surface forming a saline efflorescence if the ground was allowed to rest a few days. A large quantity of guinea grass perished, and some harriali, or dhoob, that had been planted, was not strong. A coarse swamp grass sprang up, which is known as cow grass (*Chloris barbata*), and is liked by cattle though unsuitable for horses. Moreover, the surface sank irregularly, throwing out the grading of the beds and necessitating a large amount of manual labour. Later on an inspection was made by an agricultural expert, who traced the main cause of the want of success to the sub-soil water, which was found in some parts of the farm at from four inches to two feet from the surface. The worst parts of the farm were under-drained at intervals of six feet with pipes running four feet from the surface, which was raised by the deposit of rubbish, and after this no further difficulty was experienced. My own opinion is that the drain pipes in this case were of little or no use, as they were placed below the level of the sub-soil water and had no outlet. The whole neighbourhood is low and swampy and at the present time water is found at from eighteen inches to two feet from the surface.

The next experiment was made in 1870 at Krishnampett near the sea-shore. Half the land taken up consisted of pure sea-sand, the remainder of land which had been reclaimed with rubbish and covered with a thin stratum of sand. Here no difficulty was encountered, the soil being porous and permitting the great desideratum of sewage farming—free downward percolation. Heavy crops were soon raised amounting in 1871–72 to about 69 tons of grass per acre. Since then a number of farms have been started, the principal one being known as the Black Town farm. This is admirably situated on the beach $2\frac{1}{2}$ miles north of the town. It is so close to the shore that last year a considerable portion of it was carried away by a heavy

sea. The farms now in use and the areas they drain are shown in dark and light colors on the accompanying map. It will be noticed that some of them are in inhabited areas and are of comparatively small size. This is due to the want of any general system of drainage in the town. In my opinion the fundamental principle for any system of sewerage for Madras should be to carry all the sewage to the north and dispose of it on one large farm, which could be made by the extension of the present Black Town farm. This would be more economical and in other ways preferable to having a number of small farms scattered over the town.

Successful sewage-farming is to a considerable extent dependent on physical conditions. The geology and surface of Madras are thus described in a recent report by Mr. Edward Cousins, C.E.:—"The surface and sub-soil consists, as a rule, of deposits of white and grey sand in which occur at irregular intervals thin beds of clay. Water is found below the surface at varying depths but generally in the low-lying parts of the districts it corresponds with the mean level of the sea. At no part of this sandy plain are there any considerable elevations of the surface, the maximum heights are from 20 to 24 feet above mean sea level, while many portions of the town are only two feet to six feet above that level. The average elevation of the surface may be taken at about nine or ten feet." The higher parts of the town, being principally occupied by private houses with large compounds, have no drainage system, provision only being made for storm water. The parts providing sewage to be disposed of are all if anything below the average height given, which necessitates the lifting of the sewage by pumps, either from central pumping stations or from wells on the farms, which is a costly undertaking. At first only the water-lift of the country was used. This is known as the 'picottah' and consists of a lever balanced on a strong upright and worked up and down by men stepping from one side of the fulcrum to the other. But for any kind of manual pumping to be successful constant supervision is required, and now for the principal farms this primitive system has been superseded by the steam-pump, which is in every way more satisfactory. Gwynne centrifugal pumps have been found to answer best. The Ráyapuram pumping station, from which the sewage of Black Town is pumped to the Black Town farm, is fitted with three of them, each fifteen inches in diameter. The sewage is lifted from a well, into which three sewers empty their contents, and discharged into a cast-iron main 24 inches in diameter and about a mile and a third in length, being carried the remainder of the distance of $2\frac{1}{2}$ miles in an open masonry channel. No further lifting is required after the sewage reaches the farm. Pumping at this station is carried on on an average $22\frac{1}{2}$ hours daily, the amount of sewage pumped being about three million gallons. Night-soil is removed on the pail system and is not supposed to enter the drains, though the urine and washings of the latrines do so. The annual rainfall varies considerably, the average being about fifty inches, which is above the general average for India. A very large proportion of it falls between the middle of October and the middle of December.

As I consider the Black Town farm to be a fair model for an Indian sewage farm, I shall describe it somewhat in detail. The general arrangement is shown in the accompanying plan. The sewage passes from the outfall channel through culverts with sluices into the main carriers. These are banks of earth with a channel scooped out on the top. They run in parallel lines about 432 feet apart, giving off at right angles the secondary or distributing carriers, which are similar but somewhat smaller. The interval between the distributing carriers is 114 feet, and it is divided into two by a small bund, which runs through the beds half-way between them. This may be called the central bund. The beds slope down to it from the distributing carriers. It is absent in some of the farms, but I think it is a good thing to have it, as the grass may rot at the lowest part of the slope through the water standing there longest. It percolates through the bund, and so this is avoided. There are further bunds at intervals of six to eight feet running from near the distributing carriers down to the central bund. These are small and not more than four to six inches in height. They conduce to the equal distribution of the sewage over the grass. The junction of a distributing carrier with a main is made with a stoneware drain pipe of about six inches diameter. Grass grows freely over the bunds and over the carriers to the very edge of the channels, which become coated with a black sludge, which

hinders the sewage from sinking in though it allows enough percolation to keep the grass growing freely over them. Large drain tiles have been laid in some of the carriers, but they soon get displaced and serve no good purpose. The gradient of the carriers should be sufficient to ensure a fairly rapid flow without causing a scour. Where the amount of sewage to be disposed of is small, the beds should be made somewhat smaller than the measurements I have given, in order to get even distribution. The slope from the distributing carrier to the central bund is about 1 in 30.

The system of irrigation which has been found to answer best is to flood the beds heavily every three or four days, though it can be done oftener without any ill-effect. The method employed is to open the sluice in the outfall channel and let the sewage run into a main carrier. The drain pipes leading to the distributors to be used are left open; those which are not to be used are closed with earth and grass. If only the first part of a main carrier is required it can be bunded across at the required distance with earth. The same can be done with a distributor, which is then breached behind the barrier, and the sewage pours out and runs down the space between the distributor and the ends of the bunds that divide up the beds, and turns off between these bunds to run down the beds to the central bund. The men in charge of the farms say that they put on about four inches at a time, but the amount must be much larger as a good deal of sewage sinks in before it begins to lie on the surface. This method of intermittent irrigation economises the labour on a large farm, as only a third or a quarter of it has to be attended to every day. It also gives plenty of time for air to be drawn into the interstices of the soil and provide the oxygen which is necessary both for nitrification and the formation of tissue. Most cultivators irrigate equally all the time a crop is growing, but one of great experience told me that the younger the grass the more sewage it would take. The grass should not be irrigated for two or three days before it is cut. This allows it to harden, and though it does not weigh quite so much its quality is better and it does not wither so quickly. After the grass is cut, which is done in Madras with a sickle with a saw edge, the teeth being set the contrary way to an English saw, the ground should lie fallow for the best part of a week. The careful farmer will then take the opportunity of forking it and loosening the roots, though in some farms this is not done more than once a year. It favours the development of young roots to replace the old ones, and so preserves a healthy and vigorous growth. The beds should also be weeded. If this is done regularly it entails very little labour, but if it is neglected there may be some difficulty experienced. The grass is generally cut rather before it reaches maturity. The contractor reckons to cut a crop every 45 days, which gives eight crops a year. In the Municipal parks, where sewage irrigation is carried on, we do not get quite so many. The method of irrigation by blocking the channels with earth and breaching them is primitive, but it suits the native cultivator, who is very skilful with it, and it has been found to answer the purpose, so no attempt has been made to supersede it and introduce iron or wooden stoppers.

Some of the three million gallons of sewage daily pumped at the Ráyapuram station is drawn off to irrigate the Robinson Park, the remainder goes to the Black Town farms. Adding together the area of the park, the farm, and of certain private lands adjoining the farm which are irrigated by the contractor, we get a total of forty acres approximately. This gives a daily average of 75,000 gallons per acre. The experience of the Berlin farms is that not more than 2,000 to 3,000 gallons of daily sewage should be allotted per acre, so that the land may have the necessary periods of rest. At the Bedford farm in England about 5,200 gallons per acre are pumped daily and at the Beddington farm about 6,600 gallons, which is the largest amount I know of outside Madras. Yet the Madras contractor, who is getting twelve times as much sewage per acre as any European farm would stand, recently petitioned to have sewage irrigation stopped in the Robinson Park on the ground that he was not getting enough. This is a remarkable testimony to the porosity of the soil and the copious evaporation and transpiration that take place under the influence of the Indian sun. At times when I have visited the farm, especially after heavy rain, all the sewage was not being used, the surplus running into the sea at a point beyond the farm. The sewage which is used to irrigate the farm does not form a definite effluent,

but on careful examination I have found tiny rivulets trickling down from near the bottom of the wall of sand in which the farm ends where it drops down to join the sea-shore. The amount is so small that it was a long time before I noticed it.

As regards the crops that do best, though it has been found that nearly everything will grow under sewage irrigation, later experience has confirmed the verdict of the early experimenters in Madras, that harriali grass (*Cynodon Dactylon*, Hind.: Dhoob) is by far the most satisfactory. It has the advantage of being indigenous, for English and French experience has shown that the peculiar crop, whatever it may be, that suits the neighbourhood, seems to flourish under sewage. It is, moreover, a voracious feeder, and is not easily killed by excess of sewage. In the wild state in places where there is not much moisture it creeps for the most part below the surface of the ground. Native ponies may be seen scraping the surface of the ground with their hoofs and blowing away the dust to get at it, and will graze where there is not a blade of green grass to be seen. But, when abundantly irrigated it shoots up to a height of two feet or more and yields most luxuriant crops. Captain Horace Hayes, F.R.C.V.S., says of it in his book on "Horse Management in India": "In good soil when cultivated it loses its creeping character and grows like English meadow grass, to which I think it is much superior." A good farm yields about 45 tons of green grass per acre, which dries down to about 15 tons of hay. This compares very favourably with the Berlin farms, which yield 25 tons of grass or 5 tons of hay. From this it would appear that the grass grown in Madras contains less water than that grown in Germany. The English sewage farms yield about the same amount of hay as the German ones. This is about double the yield from English meadow land. So where we get one ton of hay from meadow land, we get two tons from European sewage farms and six tons from Madras sewage farms. This enormous difference may partly be attributed to the season of growth being continuous in India, whereas in Europe it is limited to the summer months, and partly to the fact that a high temperature in a soil or water up to 99° Fahrenheit increases the activity of nitrification and consequently of vegetable growth. The hay from the Madras farms is mostly sold to the Commissariat at Rs. 45 a ton. This gives an average money yield of Rs. 675, or about £37 sterling per acre, taking Rs. 18 to the pound, against £18 per acre, which is reported to be the average price of Italian rye grass grown on the Bedford sewage farm. When the differences in the cost of land and labour in the two countries are taken into account, it is easily seen how it comes to pass that sewage farming is so much more profitable in India than in England, for we have double the produce on probably less than a quarter the outlay. Besides the supply of hay to the Commissariat there is a fair market for grass and hay among horse-owners in the city, especially during the hot weather when grass is scarce.

With regard to the quality of our sewage-farm hay as forage, I wrote to Veterinary Major W. Gladstone, A.V.D., the officer in charge of the horses of His Excellency the Governor's Body Guard and the Royal Artillery at Saint Thomas' Mount, who replied:—

"Since hay from the sewage farms has been used at the Mount there has not been a single case of anthrax until this year, when on inquiry I found that one of the Majors was using grass-cutters' grass. This was stopped and since then we have not had a case. The same in the Body Guard. I strongly recommend hay from the sewage farms, as diseased cattle are not allowed to stray over the land, and it is by far the best forage you can get in Madras. Veterinary Colonel I. S. Shaw says that wherever dry hay has been used anthrax has not been known, and certainly I have not seen a case. In Belgaum in 1878 we had anthrax, and as soon as the grass-cutters were discharged it ceased and has not recurred since. The same in Bangalore, except when they are compelled to use green grass, as in camps of exercise, &c. So I believe the drying process and keeping diseased cattle off the land has a great deal to do with this immunity."

Other Veterinary Surgeons with whom I have discussed the matter have spoken equally in favour of sewage-farm hay.

Harriali grass grows better from roots than from seed. The roots should be planted in rows about six inches apart. It spreads quickly and in about two months a light crop can be cut. If it is planted in a soil recently made by the deposit of rubbish

the irrigation should be somewhat excessive; daily will not be too often. Otherwise the heat due to fermentation may kill the grass. It is advisable to let rubbish rest for six months or more before planting it, otherwise the level of the beds may be thrown out through its sinking irregularly. After planting, if the beds keep their level, there is nothing further to be done beyond weeding and forking. Beds, both of sand and of made soil, planted more than 20 years ago, are still yielding good crops, though, so far as I know, they have never been ploughed up or replanted. If a bed sinks in any part, a few cart-loads of rubbish will restore the level. If caterpillars appear, as they occasionally do about the end of the rainy season, a little freshly slaked lime will quickly put an end to them, failing which ashes are as good as anything.

About 50 acres of land are leased to a contractor. The amount was larger, but two farms have been abolished as the sewage supplied to them was carried to the Black Town farm after the opening of No. 2 sewer, and a considerable portion of the Black Town farm was carried away last year by the sea. Eleven acres more are being acquired, to be added to the Black Town farm. The contractor also irrigates about 20 acres of private land, part of which he leases from the owners and part he holds under an agreement with the Commissariat. The land in three public parks which is worked departmentally brings the total area up to about 100 acres.

Complaints of nuisance have been made against some of the Madras farms as against most sewage farms in other places. There is an ammoniacal smell from the sewage wells and main carriers at times, but apart from this the air over the farms themselves seems perfectly fresh and wholesome. No one with his eyes bandaged could perceive by the sense of smell that he was walking over a sewage farm. With regard to the sanitary aspect of the question there have always been differences of opinion. The Sanitary Commissioner for Madras appears to have a bad opinion of the Madras farms. For in his annual report for 1893, page 115, he writes: "Madras town pursues the system profitably but on bad sanitary principles; the sites being often within inhabited areas, no arrangement being made for underdraining and discharge of the effluent and in certain cases disposal by soakage in the neighbourhood or discharge into the Cooum being allowed during intermitting working of the pumping machinery." For my own part I think the Black Town and Kristnampet farms would compare favorably with farms in any part of the world. I cannot understand on what ground a charge of bad sanitary principle can be preferred against them. With regard to some of the farms being within inhabited areas, I have not found that the health of the people living near them is worse than elsewhere. Taking cholera as a disease specially prone to appear under insanitary conditions, spot maps showing the mortality do not indicate that the disease has shown a special preference for the neighbourhood of the farms. There is nothing to show that diarrhœa, dysentery, typhoid, or diphtheria specially affect these localities. Dr. Alfred Carpenter, who has had a practical experience of 30 years or more and made a special study of the question in connection with the English farms, lays it down as a proposition "that the judicious application of sewage in close proximity to dwelling-houses does not depreciate the health of the inhabitants." "In no single instance," he said on one occasion, "out of nearly 100 cases in which sewage has been utilized by broad irrigation has any fact been proved to establish the allegations of 'insanitariness' which are sometimes brought against them." There is a Female Orphan Asylum with 200 inmates on the border of the Croydon farm and the health of the children is said to be unaffected. Many Lunatic Asylums utilize their sewage on their own grounds with excellent results. The General Hospital, Madras, has diverted its sewage from the river Cooum and employs it to irrigate a strip of land close to some of the buildings. The result is a vast improvement to the appearance of the place, and I have not heard that any complaints have been received from the Medical or Surgical staff that the health of their patients has been injuriously affected. I think they give Surgeon-Colonel Price considerable credit for the innovation. It will be seen from the map that most of the farms within inhabited areas are small. Most of them are irrigated only by means of picottahs, which limits the supply, and I believe that in India unless the supply is very abundant very little, if any, water reaches the sub-soil water. These farms will doubtless be abolished and the Black Town farm

extended when a comprehensive system of sewerage is introduced. For the present I believe they serve a useful purpose in utilizing sewage that would otherwise be discharged into the river or canals or soak into and pollute the ground. With regard to under-drainage, its objects are to prevent the soil from becoming water-logged, which ruins the crops and prevents the proper exercise of its purifying action on sewage, and to enable a larger quantity of liquid to be disposed of. It has never been successfully employed in Indian agricultural operations. In a trial made at the Saidapet experimental farm it was found that its efficiency was destroyed through the pipes getting blocked by white ants, &c. It is quite unnecessary in a highly permeable soil that permits free percolation. In the Berlin farms it was not adopted at first, but was subsequently resorted to when the soil got water-logged, 2-inch pipes being laid 16 to 33 feet apart at an average depth of three to four feet. In most of the Madras farms there is no water to be found under five or six feet and I have dug down to a depth of ten feet close to where irrigation was being carried on without getting any accumulation. There is no impervious stratum under them for a considerable distance down, D'Mellow's road being an exception, as it has an impervious stratum and is only slightly raised above the surrounding swamp. In England and Germany it is found that less than half the sewage used for irrigation flows away as an effluent. In India the proportion must be very much less, as evaporation and transpiration are enormously increased under the influence of the tropical heat.*

This enables us to use large volumes of sewage for irrigation without underdraining and without appreciably raising the level of the sub-soil water. I know of an instance in which a small sewage farm was started which was irrigated daily. A well within a few yards of the farm, which was used for irrigating a plot of grass, had to be deepened to get water enough for the purpose, which would not have been necessary if the sub-soil water level had been raised by the percolation of sewage through the ground exceeding the amount given off by evaporation and transpiration. In India, if the sewage to be disposed of is too much for the land, it is better, where it is possible, to extend the farms, rather than to increase the effluent by underdrainage. The drains leading to the Napier Park and People's Park have over-flows into the Cooum, by which sewage enters the river at night, when the pumps are at rest, or during heavy rains. So have the drains leading to two small picottah farms, Pudupet and Dam's road. It is proposed to introduce storage tanks to intercept the sewage that now escapes into the river, which is inconsiderable in amount. I do not know what is referred to by disposal by soakage. In some parts of the town there is soakage, but this is due to the want of proper drains and not to sewage-farming on bad sanitary principles. Sewage-farming can only be held responsible for the disposal of sewage when it reaches its destination and not for defects in the sewerage and drainage of a town.

The price paid for land for sewage-farming in Madras has not been high, and from what I have seen of other Indian towns, I believe that cheap land suitable for the purpose would generally be procurable. In the Madras farms there are practically only two types of soil—sand and made soil. They are both porous in a high degree and to about an equal extent. To test their porosity and their purifying action on sewage I recently performed some simple experiments. I had four filters or guages

* Some idea of this can be got from the following extract from a paper by Messrs. Dawes, Gilbert and Warrington in the Journal of the Royal Agricultural Society of England, 1881:—

"As the transpiration of water in a plant is determined by light, the amount of transpiration must have some connection with the rate of assimilation and growth. When the supply of water and of soluble plant food is tolerably constant, the relation between transpiration and growth will be fairly regular. From experiments made at Rothamstead many years ago with plants grown in pots it was concluded that from 250 to 300 lb. of water were evaporated for 1 lb. of dry matter added to a plant. It may be, however, that in a soil poor in soluble plant food a larger amount would pass through the crop to yield the same amount of assimilation than in a soil well manured. The relation between transpiration and assimilation will indeed probably differ under different circumstances."

The soil in the Black Town farm containing practically no soluble plant food, the amount of water transpired might be expected to be large. Taking into account the intense brightness of the sun light it would probably be within the mark to estimate it at double the amount given above. An acre yields 15 tons of dry matter. This would give 15×600 tons of water transpired.

9,000 tons = 20,160,000 lb., or 2,016,000 gallons per annum $= \frac{2,016,000}{365}$ gallons a day = 5,523 gallons a day.

The amount lost by evaporation in India which averages 0·22 of an inch should be added to this. This is 49,280 gallons an acre and is probably more than actually evaporates, as water is not always standing on the beds. On this reckoning transpiration and evaporation together would daily amount to 54,803 gallons per acre, or more than two-thirds of the sewage water allowed for irrigation. 21,197 gallons would be left to join the sub-soil water. The amount lost by transpiration is probably more than the estimate taken.

made, each consisting of three 9-inch drain pipes joined together and cemented so as to form impervious cylinders rather more than six feet in length. These were placed perpendicularly on wooden stands with perforated iron plates intervening and galvanized iron buckets placed underneath. Two of these I filled with earth from the Robinson Park and the other two with sand from the Black Town farm, first putting a few pebbles and pieces of broken pot at the bottom. On the top I put grass from the farms, partly as I believed it would act as a strainer, partly in order to obtain any action the roots might have upon the sewage as it passed over them, and generally to reproduce as nearly as possible the natural conditions of a farm. The soil of the Robinson Park was originally street sweepings; it is now a rich and friable loam of a dark brown colour. The soil of the Black Town farm was originally sea-sand, and as far as its physical characters are concerned it has practically undergone no alteration though subjected to sewage irrigation for over a decade. I put sewage in at the top and caught the effluent water in the buckets at the bottom. The time taken by the sewage to pass through varied somewhat, its first appearance being in two to three hours when the soil was comparatively dry and half to one hour when it was fairly moist at the time of starting the experiment. It passed through the made soil quite as quickly as through the sand, which was contrary to expectation. I began by putting two gallons of sewage, pint by pint, into each filter. About half of it was absorbed by the soil almost immediately, the remainder stood on the surface and percolated down much more gradually. As soon as it began to come through the first filter I added a gallon more to each in order to get enough effluent for analysis. I sent samples of the sewage used, which was taken from the well in the Ráyapuram pumping station, and of the effluents, to Surgeon-Major J. L. VanGeyzel, M.B., F.C.S., &c., Chemical Examiner to Government, who very kindly analysed them for me. The following are the results of his analysis:—

Analysis.

Parts per 100,000.

	Suspended solids.			Dissolved solids.			Chlorine.	Free ammonia.	Albumenoid ammonia.	Nitric acid.
	Organic.	Inorganic.	Total.	Organic.	Inorganic.	Total.				
Filtered effluent sandy soil from Black Town Sewage Farm	0·100	1·600	1·700	205·000	555·000	760·000	269·800	0·120	0·220	8·670
Sewage from Ráyapuram Pumping Station ..	12·700	19·700	32·400	66·000	299·000	365·000	170·400	5·200	0·560	0·210
Filtered effluent (No. 1 Filter) made soil from Robinson Park Sewage Farm	Trace.	0·200	0·200	117·000	304·000	421·000	138·400	0·024	0·056	16·920
Filtered effluent (No. 2 Filter) made soil from Robinson Park Sewage Farm	Trace.	0·400	0·400	105·000	280·000	385·000	120·700	0·019	0·064	16·500

The character or source of the organic matter cannot well be inferred from the above analysis in the absence of determinations of the amount of organic carbon and nitrogen present. Owing to the short space of time unavoidably allowed to the analyst, these determinations had to be omitted. The filtration performed in the experiments was necessarily imperfect. The soil in the filters was much less compact than that in the farms, where it had been rained upon and irrigated for years. If I had had the means available of isolating sections of the farms without disturbing the soil and had been able to utilize a larger area in proportion to the sewage used, I believe that the effluents obtained would have been purer. The sewage put on—2 gallons to an area of 63·6 square inches—is equivalent to 591,750 gallons an acre, which is seven times as much as the average daily amount used on the Black Town farm, or more than twice the amount used at a flooding done every three days. The sample

of sewage analysed contained rather less suspended matters and free ammonia, much less combined ammonia and much more matters in solution and chlorine than are contained in English sewage of average composition. At the same time, the results obtained amply demonstrate the purifying powers of the soil and are in the main in accordance with the results of English experiments. The effluent water was clear, odourless and practically colourless. The analyses show that it contains less suspended organic impurities and much less free and albumenoid ammonia than the sub-soil water in parts of Black Town of which I have analyses. It would so far pass the standards of purity adopted by the Commissioners appointed to inquire into the best means of preventing the pollution of rivers. The most noteworthy point, whether from the point of view of the sanitarian or of the agriculturist, is the retention by the soil of the suspended organic matter and ammonia in solution and the appearance in the effluent of nitrates. According to modern theories based on the experiments of M. M. Schlæsing and Muntz and Messrs. Lawes, Gilbert and Warrington, this is due to nitrification brought about by the presence of living organisms, which specially occupy the first 18 inches of the top soil. The vital activity of these living ferments varies with the temperature, being very low near freezing point and reaching its maximum at 99° Fahr. I have not got reliable records of soil temperatures in Madras, but a few days ago (early in November) I took some temperatures of the soil on the Black Town farm in the early morning, which were over 80° Fahr., so that that it is probably between 80° and 100° Fahr. generally, which is the most favorable temperature for the process, and so in the highest degree conducive to the purification of sewage. In a paper read before the Society of Arts in 1882, Mr. Warrington pointed out that "a filtering medium of pure sand and limestone, treated intermittently with sewage, will after a time display considerable purifying powers, the surfaces becoming covered with oxydising organisms derived from the sewage. No such medium will, however, equal in effect a porous soil rich in organic life." This explains what might seem strange in the results of the analysis, that the effluent from the made soil contains much less unoxydised nitrogen than that from the sand. The experiments of the Rivers Pollution Commissioners with soils from different farms appear to show that the cleansing power of a soil is more closely connected with physical conditions as regards porosity and fineness of division than with its chemical composition; and of two soils not differing very widely in chemical composition, namely Hambrook and Dursley, one (the latter) was found to have twice the purifying power of the other. Judging from my experiments it would appear that made soil, which is the finer and richer of the two, had a greater purifying power than sand, and, as the porosity is about equal, though both are admirably suited for sewage-farming, where both were available made soil should be taken by preference, or sand might be covered with sweepings to a height of one or two feet to give it a more active nitrifying surface stratum. Presumably the nitrates in the effluent were in the soil when it was taken from the farm and were the result of former nitrification and not produced from the organic matter and ammonia in the sewage used in the experiments. The large amount of chlorides is probably due partly to the urine contained in the sewage and partly to the proximity of the sea. The amount in the effluent from the Black Town farm soil, which was taken from a spot about 200 yards from the sea-shore, was more than double that of the Robinson Park, which is more than half-a-mile from the sea. These experiments, imperfect as they were, and the analysis made by Dr. VanGeyzel, convince me that what little effluent percolates through our farms may safely be allowed to join the sub-soil water without any fear of polluting it or in any way endangering the public health. I have already shown good reason for believing that there is not very much of it, that the water-level is not appreciably raised, and that the crops are healthy and vigorous. Hence, so far as I can see, no reason exists for underdrainage, which would, moreover, entail great difficulties and expense; for the ground is in many of the farms so level that the effluent would not run off, so that it would have to be pumped, and there would be nowhere for it to go to unless it were thrown on to the beds again and so be sent round and round in a vicious circle.

Under the arrangement with the sewage-farm contractor the Municipal Commissioners undertake to pay the rent, establishment and labour. The contractor must keep in repair the sewers, drains, cisterms, channel-pipes and other things connected with

the delivery of sewage in or on the farms. He must dispose of as much sewage on the land as the Commissioners deliver. He must cultivate and manage the farms in the most approved manner and keep them in a clean condition, free from weeds, &c. He must allow free access to the farms to the officers and servants of the Municipality, in order that they may see in what state the farms are kept and whether any part is in need of repair, &c.; if so, to give notice to the lessee, who must execute the repairs within fifteen days. The contractor has the right of constructing new wells, cisterns, &c., if he first obtains consent for the proposed work. The Commissioners agree not to stop the delivery of sewage at any one time for a longer period than five days. The contractor is allowed to cultivate or irrigate with sewage other land than municipal land with the consent of the President, and pays to the Commissioners Rs. 250 per cawnie (1 cawnie = 1·322 acres) per annum for lands so cultivated. The contractor has to cultivate and irrigate any other land acquired, rented or handed over to the Municipality, and pays the Commissioners Rs. 300 per cawnie per annum for lands so cultivated. The contractor makes a deposit of a Government of India promissory note for Rs. 4,750 as security. Deductions may be made from this in the event of a breach of contract.

The contract system which was introduced in 1888 has been found to be more profitable than working the farms departmentally. The usual objection to it is that a contractor has an eye only to profit and will not use all the sewage on the farms for fear of injuring his crops. No trouble has been experienced from this cause in Madras, partly through the voracity of harriali and partly through the well-known prodigality of the Indian cultivator in the matter of irrigation. One contractor allowed weeds and objectionable kinds of grass to gain ground, especially a kind of swamp grass with strong interlacing roots (*Panicum fluitans*) which gained a hold in the D'Mellow's Road farm, and to a less extent cow grass (*Chloris barbata*).

The farms are put up to public auction triennially. At the first sale in 1888 Rs. 7,250 per annum, or Rs. 21,750 for the whole period, was the highest bid. On this, if the cost of pumping on the farms be included, there was a loss on the three years as shown below :—

Income.	RS.	A.	P.	*Expenditure.*	RS.	A.	P.
Rent of farms	21,750	0	0	Establishment	1,920	1	9
				Overtime	153	10	8
				Fitters staff	721	1	3
				Labour (including pumping)..	35,414	5	10
Loss	19,239	11	6	Rent of sewage farms ..	2,780	8	6
	40,989	11	6		40,989	11	6

This shows a loss of Rs. 19,239–11–6, or rather more than Rs. 6,000 a year. In 1891 the better price of Rs. 15,600 per annum, or Rs. 46,800 for the three years, was obtained. On this an actual profit of Rs. 18,307 was realised, the expenditure having been somewhat reduced. In 1894 the farms were let for Rs. 19,000 per annum or Rs. 57,000 for the three years. The following is an estimate of the income and expenditure for the period :—

Income.	RS.	*Expenditure.*	RS.
Rent of farms	57,000	Rent, maintenance, &c.	30,630
Private land	14,850		
Added land (2½ years)	5,312	Profit	46,532
Total ..	77,162	Total ..	77,162

The estimated profit for the period is thus seen to amount to Rs. 46,532.

The conclusions I draw from the evidence adduced are as follows :—

(1) Barren land can be acquired at a moderate cost in the vicinity of most Indian towns.

(2) No matter how barren the land is, if it is permeable, it can be utilized for the formation of sewage farms.

(3) Sewage farms in India can be laid out at small cost, a maistry with a gang of coolies being able to do the grading of the beds and make the bunds and channels.

(4) Owing to growth being continuous more crops can be raised in India than in Europe and sewage can be more satisfactorily disposed of in very large quantities throughout the year.

(5) Owing to the temperature of the soil being particularly favorable to nitrification and growth in the presence of sufficient water the crops are very heavy.

(6) Owing to the scarcity of good forage during a great part of the year there is usually a good market for grass and hay.

(7) Owing to the exclusion of diseased cattle from the farms the grass is not liable to infection with disease germs. The hay compares favorably as a food stuff with forage from other sources.

(8) Sewage-farming can be carried on in the proximity of houses without affecting the health of the residents, though it is better to locate the farms at a distance from a town as there may be some nuisance from the sewage wells and main carriers owing to the decomposition of the sewage before it reaches the farms.

(9) Owing to porosity of the ground and the enormous volumes of water given off by evaporation and transpiration, under-draining is not generally necessary though it may be in particular cases.

(10) Sewage after passing through the ground is sufficiently purified to be admitted into a river, or to join the sub-soil water without causing pollution.

(11) The native cultivator is quite capable of laying out farms and carrying on sewage cultivation without close European supervision. He is an adept at irrigation processes, having inherited his aptitude and familiarized himself with the methods almost from the time of his birth.

(12) The system is suitable to parts of India where the ground is permeable and the rainfall is not excessive. It can be carried on profitably even where the flatness of the land necessitates the use of pumps, and should yield a much higher profit where the natural slope of the land permits them to be dispensed with.

No. 25.

Referred to the Sanitary Board for remarks.

(By order.)

(Signed) W. FRANCIS,
Acting Assistant Secretary.

FORT ST. GEORGE,
12*th January* 1894.

To the Sanitary Board.

From Surgeon-Lieutenant-Colonel W. G. KING, M.B., C.M., D.P.H., Acting Sanitary Commissioner for Madras, Secretary (General Sanitation Department), Sanitary Board, to the Chief Secretary to Government, dated Camp, Tirupati, 10th March 1895, No. 472–S.

With reference to G.O., dated 12th January 1895, No. 25, Local and Municipal, I have the honour to forward herewith my remarks on Dr. Nield Cook's paper on sewage farming in Madras.

Remarks by the Acting Sanitary Commissioner for Madras as to Madras Sewage Farming.

Most of the matters dealt with in Dr. Cook's Medical Congress paper have been long established, and I therefore would confine attention to such unusual conclusions as I think require modification. Dr. Cook states," owing to the exclusion from the farm of diseased cattle, the grass *is not liable* [italics mine] to infection with disease germs." Because a place is styled a sewage farm and even cattle be excluded, it does

not follow that infection will not occur. This is solely a question as to what chances the sewage used had of infection and of getting rid of it before arrival at the farm. The instance given in support of this contention at page 5 of Dr. Cook's paper, simply points to the possibility of well-dried hay being a safer forage where anthrax is concerned than grass, the reason being that prolonged exposure to sunlight is inimical to anthrax spores, whilst damp grass and ill-drained soil offer conditions favourable to their vitality. Against this, however, must be placed the experience that hay by its mechanical action is by good authorities held to be likely to favour infection by the making of abrasions in the mouths of animals. In the case of a sewage farm devoid of under-drainage and subject to waterlogging as in the case of DeMellow's, anthrax spores introduced with the sewage would be in little better position than in the damp soil surrounding many of our villages. But there is this to be said; in town life anthrax blood ought very rarely to reach the drains, the animal being usually taken out entire from the neighbourhood of habitations; whereas, in the country, the cutting up of animals is practised by chucklers where the animal drops, and by this process the spores, as contrasted with the bacilli, are set free. Of course, I do not forget the claims of certain authorities that pathogenic microbic life suffers in sewage farms as a result of crowding out by saprophytic germs and alkalinity of the sewage; but, on the other hand, I cannot so far forget the highly-resistant character of the anthrax spores, and the variable factors that have to be dealt with in connection with sewage farming, as not to consider Dr. Cook's assumption that sewage farms are "not liable" to infection as dogmatic, and likely to lead to serious neglect of requisite precautions.

Again, he affirms that "sewage farming can be carried on in the proximity of houses without affecting the health of the residents, though it is better to locate the farms at a distance from the town as there may be some nuisance from the sewage wells and main carriers owing to decomposition of the sewage before it reaches the farms." To assign as the sole reason for removing sewage farms from inhabited areas that "some" nuisance may result from the main carriers is to say the least regarding a serious sanitary question lightly.

Dr. Cook quotes, as supporting his contention as to innocuousness, Dr. Carpenter's conclusions as to the Croydon farm. That enthusiast would have had us believe that either the grass seized disease germs, or that they committed suicide by entering into the grass! But here is what the Medical officer (Dr. Creasy) of the Orphan Asylum, mentioned by Dr. Cook as being in the neighbourhood of the farm, reports on the subject—"typhoid fever has been in every cottage on the estate." The Medical officer of Health, Croydon, also some time back persisted, in spite of Dr. Carpenter's opinion, in regarding the presence of the farm as influencing the propagation of scarlet fever in the vicinity. Again, we have the classical instance of the Cumberland and Westmoreland Lunatic Asylum, where dysentery was traced to mismanagement of the sewage farm. Pasteur's recent protest against sewage farming in the vicinity of Paris also cannot be ignored. The evidence produced by Dr. Cook as to the innocuousness of the Madras sewage farms is unfortunately of little utility. Such a matter cannot be approached without correctly-worked out statistics; loose statements can be of no value in deciding so important a question. That he might have difficulty in a town having a mortality of over 40 per mille in finding that the localities of sewage farms are specially affected with certain diseases I can well imagine, the condition of the sub-soil of Madras generally being that of a badly-managed sewage farm; but to deduce statements as to safety, applicable to India generally, from observations made in so insanitary an area as the Madras Municipality would demand a very close study of refinements in vital statistics.

His conclusion that, "owing to porosity of the ground and the enormous volumes of water given off by evaporation and transpiration, under-draining is not generally necessary, though it may be in particular cases," seems to me to exhibit confusion of ideas as to the functions expected of under-drainage. It stands to reason that the greater the rate of evaporation the quicker will porosity diminish simply from rapidity of deposit of sludge on the soil surface; porosity being diminished, the greater would be the urgency for under-drainage in reference to nitrification.

Another conclusion of Dr. Cook's is as follows:—"Sewage after passing through the ground is sufficiently purified to be admitted into a river, or to join the sub-soil water without causing pollution." This is a most dangerous generalization. Of investigations as to the influence of filtration of sewage through soil, there is endless evidence from the time of the Rivers Pollution Commission downwards. No more complete testimony can possibly be quoted than that obtained through a series of years, aided by all the resources of modern science, than the investigations of the Massachusetts Sanitary Board. Their chemical and biological examination of filtrates of sewage, under every conceivable condition, amount to many thousands. The utmost any expert on this subject has hitherto ventured to affirm, nevertheless, in view of this mass of evidence, is that as a result of filtration through soil there is secured one of the best practicable methods of purifying sewage; but no one has yet been found who would assert that in the filtrate joining either sub-soil or rivers "pollution"—in whatever sense that term open to most varied interpretation, is applied—does not occur, or, that its freedom from disease-bearing agents is so absolute as to warrant its being stated that it is incapable of "in any way endangering the public health."

That many important towns in civilized countries are obliged to get rid of their effluent into rivers is a matter of necessity, and is accomplished with the knowledge that dilution and the various processes of self-purification will further aid in the work of prevention of danger, already attempted by filtration through soil. The same reasoning applies to the admission of such filtrate to the subsoil water; no one would however deny that danger exists. Thus, on the Paris sewage farms, rather than run the risk of contamination of the sub-soil, it is ruled that when the effluent from the under-drains is interrupted by rise of the Seine, the crude sewage must be discharged into the river.

Dr. Cook has gone to the trouble of making three special experiments with soils from the local sewage farms. He shows that he produced a filtrate that was equalled in evil composition with that of certain waters in Black Town, and he argues therefrom that no untoward result will occur, by sewage that has passed through a sewage farm entering the sub-soil. This, of course, proves nothing; as no one would wish to affirm that the sewage sodden soil of Madras is likely to produce good water in other than unusual localities. But, to argue from such data to a general application elsewhere, is quite another matter. In the first place, in localities other than Madras such an effluent would seriously pollute the sub-soil considered merely from its chemical composition; but Dr. Cook's experiment ignores the factor upon which any evidence as to disease production must be based. Although a certain unwonted proportion of albumenoid ammonia and chlorine would certainly not improve a human being's chances against disease, the risk cannot be gauged by this, but by the presence or absence of the causative agents—that is, of specific microbes. On this important point Dr. Cook's results afford no information; the experiments of the Massachusetts Board, however, supply the deficiency. It is shown that sewage filters working under the most favourable conditions can deprive sewage passing through them of 99 per cent. of micro-organisms. But seeing that each cubic centimetre, or, say, each half-teaspoonful, may contain 1,000,000 microbes originally, the chances of specific disease germs reaching sub-soil water in the vicinity of a sewage farm can hardly be ignored; especially if this addition to the soil proceeds year after year, and there be no under-drainage to assist nitrification and to remove the effluent to the further self-purifying processes of water-courses and sunlight. But whilst this is the best result procurable, it must be remembered that 95 per cent. is in certain conditions found to be all that can be accomplished, and that errors of management reduce this enormously. When, therefore, Dr. Cook points to his three experiments as proving the safety of sub-soil water from pollution, his conclusions can hardly be said to be complete, irrespective of the circumstance that the factor of prolonged use of the filter has not been entered into. Moreover—probably unconsciously—he has in this experiment not faithfully imitated the processes which proceed on Madras sewage farms; his filter represented a farm *with* under-drainage, which he has decried as unnecessary.

His deductions from these experiments that "made soil" is rich in nitrifying organisms is universally acknowledged, but I cannot help thinking his advice to

imitate its efficacy by using *two feet* of "sweepings" over sand goes beyond solid facts. If there be a large amount of nitrifying microbes in such a mixture, so also have they a large amount of organic matter to get rid of without its being added to by sewage being forced upon it. In short, with two feet of ordinary Madras town sweepings above a layer of sand, the latter would find its work of purification pretty well cut out for it in disposing of the filth—including fœcal matter—brought from this source alone. Instead of thus trammelling biological action, experiments show that by permitting the entrance of oxygen within the soil voids by quickly depriving it of excess of moisture, air finds entrance and *thus nitrification can be best supported*—an effect that can be brought about by under-drainage. Dr. Cook's further inference that if he had possessed a filter with earth more compact * as in the case of soil of the farms that had been long used he would have secured better results chemically, is also not in accordance with actual testing of such comparative conditions nor with the theory of nitrification just alluded to.

When, however, applying experimental results to practice, it is hardly necessary for me to say that the sub-soil of towns does not always fulfil the condition of a neatly-constructed filter, such as depicted in Dr. Cook's diagram. There are few sub-soils that have not faults, varying levels, and crevices that would guide, or permit to pass, sewage before it has undergone purification. Thus, places distant from the point of deposit may by sub-soil soakage be contaminated with sewage, and every year that a patch of soil receives filth and is taxed to purify it, there is ample proof that the greater liability is there for sub-soil pollution. Once a pathogenic microbe has successfully run the gauntlet of the upper 18 inches of soil teeming with saprophytes, the chances of being carried forward with the sub-soil water, and being aided in multiplication by the presence of nitrates from the sewage filtrate, are favourable. The classical instance of the Lausen typhoid epidemic showed that by irrigation of the soil surface, the typhoid bacillus can be sent through *a mile of sub-soil*.

In consideration of the fact that sewage reaches the soil of Black Town from other sources, I by no means wish to lay the blame solely to sewage farming, or solely to the fearful mass of diluted sewage collected in the Versarpady tank—*vide* Photograph No. 11—that escapes treatment on farms between Pursewalkum and Cochrane's Canal, but it is indubitable that within the last few years the "Seven Wells" water has deteriorated in quality. Further, coincidently with a fall of the sub-soil water—though not proved necessarily to be depending on this cause—typhoid fever increased amongst British troops using it to a lamentable extent. These wells are in a line with the sub-soil water flow from the points of pollution named. Whether or not the troops obtained the specific disease of typhoid from these waters, the progressive defilement which the wells have undergone, as proved by chemical analysis, shows that allowing sewage to pass through earth, whether the site be called a sewage farm or a street, matters little, and that, as time advances, if the filter be overtaxed, pollution of the sub-soil water results. Indeed, I should think that the mere *possibility* of defective filtration through the surface soil permitting pathogenic germs to pass, should forbid sewage farms being placed in a position in which they could add *in any degree* to the impurities of the sub-soil of an inhabited area. I would point to the fact that if the Health Officer's spot-map of the epidemic of cholera of 1892 be examined, it will be found that there was decided preference for the disease to flourish in those parts of Black Town within the sub-soil flow of the insanitary areas I have alluded to. I noticed this tendency of the disease in my investigation of the epidemic of 1882 (*vide* my Report thereon) and regarded preference of the disease for the parts near the sea coast as due to the increasing increments of filth brought by the sub-soil flow thither proving an auxiliary cause of propagation in the presence of the cholera microbe.

In this connection, it is well to remember that certain of the Madras sewage farms are formed, as Dr. Nield Cook would advise, of town rubbish; that is to say, in the special case of Madras, of a very large amount of fœcal matter *plus* rubbish. This

* To prove that the process of purification did not depend upon the compactness of the pores though which sewage was passed, the Massachusetts Board used gravel stones of the size of beans, which were previously washed free of all sand. The Board concluded that "the removal of this organic matter is in no sense a mechanical one of holding back material between the stones, for they are as clean as they were a year ago; but it is a chemical change, aided by bacteria".—W.G.K.

process is shown in Photograph 9. In this instance, the dumping has been effected so as to build in the walls of native huts! Possibly, the Health Officer trusted to the powers of ten inches or so of mud wall between the coolies and this filth, to protect them from disease germs. But, granted public bodies made, as they should, their farms of clean material, if necessity compelled their use within the water-shed or sub-soil flow of inhabited areas, I need hardly point to the danger of their being informed that it is safe for a population depending on well-water to so risk its contamination. In this connection, it must be remembered that few of our towns are yet provided with public water-supply systems. To argue that in the absence of a correct sewerage system, disposal of sewage on farms within inhabited areas on sites as completely out of the direction of the sub-soil flow through the town as feasible is justifiable, is the utmost that can be said; but to attempt from faulty data at disposal in the town of Madras to teach the people of India that to retain sewage farms in the midst of inhabited areas is neither to risk health nor the purity of well water, is subversive of the ordinary principles of hygiene.

It would have rendered me more capable of understanding the "strong opinions" I am supposed to have "inferentially" stated, had the Health Officer taken the trouble to speak of sewage farms within inhabited areas and those without. To the former, my remarks as to absence of under-drainage are obviously applicable. As to proposing under-drainage at the time of writing, I had no such intention; I simply described the condition of these farms with reference to sanitary results on their surroundings as aggravated by there being no under-drains. When my Annual Report was written, I had every reason to hope that Government would adopt the recommendation of the Water-Supply and Drainage Committee of 1890 (of which I was a member), and would abolish all farms within inhabited areas—a recommendation Dr. Nield Cook would now seem to coincide with, although it seems to me a surprising position to be assumed in view of his declaration of their innocuousness. But, in view of the change of intention of Government as to carrying out Mr. Cousins' sewerage scheme, of which I have been since informed, the question of the advisability of correcting the evil conditions that have been allowed to exist on the farms in inhabited areas ought certainly to be considered. Where I think this action desirable, I will state further on.

Dr. Cook attempts to be-little the effects of under-drainage in a manner that ought to have no influence upon his readers. After stating that under-draining had been employed in a portion of the DeMellow's farm, he gives it as his opinion that "the drain pipes in this case were of little or no use, as they were placed below the level of the sub-soil water and had no outlet."

Now, it seems to me most unlikely that an engineer would have laid down sub-soil drains without an outlet, whilst, even if this were so, the drains would not have been without a certain amount of influence in facilitating air change and water subsidence. At any rate, here is Mr. Lee's statement of the results, which I extract from a very interesting report written on sewage farming in Madras by that officer in 1872:—

> "This gave the key to our action. That part of the farm where we could get absolutely nothing to grow was, on Mr. Robertson's recommendation, immediately broken up to a depth of 18 inches and drained every six feet with pipes four feet under the ground level. With marvellous rapidity we obtained an excellent crop of grass. This advance has been maintained, and these beds are now one of the most productive portions of the farm. The supply of pipes running short, many of the beds were drained less thoroughly by a layer of loose brickbats about six inches in depth placed at the bottom of the drain-cutting and then covered in. In others a thin earthen tile was placed at the bottom and the loose brickbats placed upon that. The closeness of the drains made up for their imperfection and that portion of the farm is now almost too well drained, since the sewage runs through so freely that a large flow is necessary to ensure that the lower end of the bed shall be irrigated. Such careful and thorough drainage is costly and requires much time. There has been

throughout the year when they cease. Last year, during my inspection, I found no sluice-gate on this conduit, and the sewage extended over the whole of the ground seen in the photo and along the road towards the People's Park. In the face of these facts, I fail to understand Dr. Cook's denial of disposal of sewage by soakage on the soil, that it is the function of these sewage farms to deal with in a safe manner. If they do not fulfil this function they must forfeit the pretence of being sewage farms at all. The argument advanced that these inferior arrangements serve to prevent a certain proportion of crude sewage going where it should not, is merely begging the question. Indeed, the concession of the President and Health Officer that larger storage reservoirs are requisite in connection with these farms, is of itself a sufficient indication that my remarks are well justified.

Dr. Cook maintains, in spite of the conditions above described, that under-drainage is "unnecessary," and that the levels of "some" of these farms in inhabited areas will not permit of under-drainage; but the converse is also true. DeMellow's farm is in part under-drained, and no one can doubt, therefore, that its application throughout is feasible. Again, it is evident that the sewage plot shown in Photo No. 6 will permit of under-draining. In certain of the farm plots on the banks of the Cooum and Cochrane's Canal, it could also be applied.

If sewage farms are to take rank as sanitary works, they must be so arranged as to discharge no sewage that has not passed through the soil or over the soil, — in the latter case only after prolonged contact, proved by a series of analysis, during a considerable period, in the case of each farm, to be sufficient. If the ground at disposal at any point — for example, at Perambur Barrack Road bridge—be too limited to receive all the sewage, mere farming should be abandoned, and the sewage should be submitted to a correctly-prepared under-drained sewage-filter which would fulfil requirements. Indeed, although, as I have already stated, I had no intention of recommending under-drainage or any improvement in farms that at the time of my writing my Annual Report I hoped would be abolished, in the absence of the possibility of Mr. Cousins' scheme being completely effected, I would now advise that in each sewage farm near inhabited areas, in addition to plots for irrigation, special portions should be under-drained and prepared as sewage-filters to receive flow during rainfall, and when it is not required for the crops. As a necessary adjunct, either the collecting reservoirs should be enlarged as suggested by the President, or, what is better, labour should be employed for sewage-lifting during a greater part of the twenty-four hours than at present; or, as circumstances demanded in individual cases with regard to efficiency and economy, both arrangements should be adopted. This probably, in the case of Madras, is a fair compromise, with a sewage system within measurable distance; but, putting aside this special case and dealing with the general principles which Dr. Cook enunciates, I regard it as essential that where a public body is compelled to dispose of sewage on a farm *within inhabited areas*, as a result of the absence of a correct sewerage system, it also should do its best to protect the inhabitants by arranging for under-drainage, not only with the object of removing effluent, but of accomplishing purification in the most complete manner reasonable and practicable. It seems to me that it is due to a failure to appreciate the full importance of using the best means available, that I am indebted to the Health Officer for his protest. The securing of circulation in the soil by under-drainage where purity of effluent is aimed at, especially on limited areas, is as essential as respiration to a human being, to which function the access of oxygen to the soil voids, enabling nitrification to be effected, has been aptly compared.

I see no reason whatsoever, from a perusal of Dr. Cook's Medical Congress paper, to modify my opinions that, whilst the Madras Municipality have so managed their farms as to prove them a financial success, these are worked on very bad sanitary principles; it being absurd to suppose that a sewage farm meets sanitary requirements unless it is capable of disposing with safety to the population *on its soil at all times* *all* sewage intended to be dealt with by it. Of what utility, except for economic purposes, can a sewage farm be which every seventh day refuses to purify its sewage, and pours it in a crude state into a stagnant pool that extends through the breadth of

a thickly-inhabited city! In short, all that can be said as to their management is that farming with sewage is pursued — *sewage farming* in the sense accepted by sanitarians.

(Signed) W. G. KING, Surgn.-Lt.-Col.,
Sanitary Commissioner for Madras,
Secretary (General Sanitation Department), Sanitary Board.

6th February 1895.

Order—dated 10th May 1895, No. 818, Local and Municipal.

The memorandum of the Sanitary Commissioner will be forwarded to the President for consideration.

2. It is understood that a committee of the Commissioners is now sitting to deal with the question of improving the existing system of drainage and that the main feature of the recommendations which it will make will be the introduction of the back-bone drains of Mr. Cousins' scheme without, for the present, the subsidiary drains and house connections. If this plan is introduced it will probably be possible to get rid of the small sewage farms which are scattered about the town and to concentrate all sewage farming on one spot.

3. But in the meantime measures should effectually stop the soakage to which Dr. King alludes and proposals for preventing the flow of any sewage into the Cooum should be considered and estimated for and the result reported to Government.

4. His Excellency in Council is not prepared to admit that under-draining of sewage farms is unnecessary. Of course if the scheme referred to in paragraph 2 *supra* is carried out with the result that the smaller sewage farms are abandoned, it will not be necessary to go to any large expense in under-draining these, though, as it will be some time before any improvement in the existing drainage system can be executed, it would be advisable, wherever under-drainage is manifestly necessary, to carry it out at once as economically as possible, soakage being in all cases promptly dealt with. Whatever course, however, is followed as regards the drainage of Madras the large farm north of Black Town will remain, and Government is of opinion that very early steps to under-drain this and discharge the resulting effluent into the sea should be taken.

(True extract.)

J. F. PRICE,
Chief Secretary.

To the President, Municipal Commission, Madras.
" Sanitary Commissioner.

Exd. A. Bailt.

Govt. of {1895} Madras.

LOCAL AND MUNICIPAL.

Issued

Recd. *Encl.*

G.O., 10th May 1895, No. 818 M.

MAY.

Madras Sewage Farms.

Communicating to the President, Municipal Commission, Madras, with remarks, the memorandum of the Sanitary Commissioner in connection with sewage farming in Madras.

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