Report on a project for the drainage of the town of Madras / by Hector Tulloch.

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REPORT

ON A

PROJECT

FOR THE

DRAINAGE OF THE TOWN

OF

MADRAS.

BY

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ROYAL ENGINEERS.

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Copy of Pamphlet :—"On some unsolved Problems in relation to Public Health, by WILLIAM ROBERT CORNISH, Assistant Surgeon, Madras Medical Establishment, Secretary to the Principal Inspector General, Medical Department. No. 1.—The Cleansing of Towns."

Copy of Pamphlet :—"Reports and Orders of the Madras Government regarding the adoption of the Dry Earth System of Conservancy in Barracks, Hospitals, Prisons," &c.

The Datum Line for the levels used throughout the Drawings, and referred to in this Report, is what is usually understood in

Datum for the levels.

Madras as "mean sea level." It is taken from a bench-mark on a stone fixed in the Escarp of the North Ravelin of Fort St. George. On the stone is the following inscription:

> "Mean Level of the Sea from May to October, six feet ten inches below this Line which answers to the Tide Guage mark.
>
> ---
>
> Ascertained in 1821 by Major DeHavilland, Acting Chief Engineer."

Division of the subject.

A KNOWLEDGE of the natural position and features of a town is so indispensable when the question of its drainage is to be considered, that a description of the more important physical characteristics of Madras will form the first part of this Report. The general condition of the inhabitants, *i. e.*, the number and density of the population, the construction and arrangement of the dwellings, the present means of water-supply and drainage, &c., will next be treated of. Without this information no opinion could well be formed on the suitableness of the project to the requirements of the town. The system of "Dry Conservancy," which has attracted so much attention lately, will next be discussed. I shall then endeavour to meet the "Objections to Sewers" which are occasionally urged, in consequence of the favour with which dry conservancy has been received. The rest of this Report will be confined to an explanation of the project now submitted to Government, and to questions incidentally arising out of it.

CHAPTER I.

POSITION AND PHYSICAL FEATURES OF MADRAS.

Position of Madras.

The limits of the jurisdiction of the Municipal Commissioners, or *Madras Proper* as the district contained within them may be termed, extend to the south as far as the River Adyar—in a northerly direction to within a mile of the village of Trivatoor—towards the west as far as the villages of Nungumbaukum, Chetput, Kilpauk and Perambore—and towards the east up to the sea. The area of this tract may be taken at 27 square miles. The strata in parts consist almost entirely of sand, but generally of alternate layers of sand and clay. There is no rock to be found except at a considerable depth below the surface, a depth which none of the sewers which it is proposed to lay down will approach. The town stands on a sandy plain—the lowest parts being from 2 to 6 feet, and the highest from 16 to 24 feet above mean sea level. The average level of the whole of Madras may be taken at from 8 to 12 feet above the datum line. Water is found in all parts at a few feet above or below mean sea level.

If we except the western quarter of Madras, which is so thinly populated that it is not worth while considering it as a district to be drained at present, there is no single neighbourhood which is altogether elevated above the others. In each there are high and low portions which differ from each other in height from 8 to 16 feet, but in all the districts the lowest parts, or those which must regulate the direction of the main sewers, are nearly on a dead level with each other. The lowest streets in Saint Thomè, Triplicane, Chintadrapett, Egmore,

Vepery, Pursewakum, Black Town, Tondiarpett and Royapooram, which are the important divisions of the Town, are, in each instance, from 4 to 7 feet above mean sea level. It will thus be seen that there is no natural line of drainage for the town of Madras, *considered as a whole.* This is an important point, and one of the truth of which it will be well to be convinced by a reference to the Map of Madras which accompanies this Report.* Each district, however, has its ridges and valleys which can be turned to account when we take it *by itself,* and lay down its branch sewers and pipe-drains irrespective of the other neighbourhoods.

Madras may be conveniently divided into four drainage divisions.

1st Drainage Division. Beginning from the north, the 1st, which comprises the districts of Royapooram and Tondiarpett, is that quarter of the Town which stretches northwards from the Railway and is contained between the Canal and the Sea. A ridge half a mile broad, and from 12 to 15 feet above mean sea level, runs north and south midway between the Canal and the Sea, and slopes gradually down on either side towards these boundary lines. The soil, to a considerable depth, is almost everywhere sand. The southern portion only of this division is thickly inhabited.

2nd Drainage Division. The 2nd division is that bounded by the Railway on the north, the Canal on the west, the River Cooum on the south, and the Sea on the east. It contains Black Town and Fort St. George. In Black Town there are two ridges running parallel to each other and almost due north and south. The well known street, Popham's Broadway, which is from 6 to 8 feet above mean sea level, is the valley line between these ridges. Beginning from the east, or from the road running along the sea beach, which is from 11 to 12 feet

* Vide also the Map of Madras which faces page 75 of this Report.

above the datum line, the ground rises to the west for about a quarter of a mile until the first ridge is reached, which, at its northern extremity, is 21 feet above mean sea level. From this ridge the ground slopes downwards to the west for another quarter of a mile as far as Popham's Broadway. From here the ground rises to the west for about a third of a mile, until the second ridge along Salay Street is reached, which varies in height from 13 to 20 feet above mean sea level. After this the ground falls rapidly to the west for about a quarter of a mile, or down to the Canal. Of all the districts in Madras, Black Town offers the greatest facilities for drainage. The strata found below the surface consist of layers of different coloured sand. Water is usually found at from 1 to 3 feet below the datum line.

There is nothing to note about the natural features of the Fort except a general fall of the ground towards the west.

3rd Drainage Division.

The 3rd drainage division which comprises the populous districts of Vepery, Pursewakum, Egmore* and Elemboor is bounded on the south by the Cooum, on the east by Cochrane's Canal, on the north by Captain Cotton's Canal, and on the west by the villages of Chetput, Kilpauk and Perambore. The most striking characteristic of this division is a general rise of the ground from the east to the west. In the southern portion this rise is regular and almost uninterrupted. It begins from the eastern part of Vepery and Egmore at 6 feet above mean sea level, and continues as far as the western limits of Madras till it attains a height of 24 feet above the datum line. Pursewakum alone has features peculiar to itself. Although it rises steadily to the west, there is a valley line running east and west from which the land ascends towards the north and towards the south. In other words, Pur-

* I have called the neighbourhood on the north bank of the Cooum facing the south west part of Chintadrapett, "Egmore," as it is better known by this name than by that of Poodoopett.

sewakum stands on two slopes of ground meeting in a valley—one slope faces the south and the other the north. The top of the former is from 8 to 11 feet, and that of the latter from 10 to 15 feet above mean sea level. The valley itself is from 3 to 6 feet above the datum line. On account of its great extent, it is somewhat difficult to drain the 3rd division. The strata underlying the surface soil consist in some parts of sand, and in other parts of clay. Water is found at from 1 to 3 feet below mean sea level.

4th Drainage Division.

The 4th Division is that portion of Madras which lies south of the Cooum. In it there are three populous districts, viz., Chintadrapett, Triplicane and Saint Thomè. The former slopes down from 9 to 10 feet on the west to 5 feet above mean sea level on the east. The land on which Triplicane stands is perhaps the most irregular in Madras. It rises and falls continually, and yet there is hardly an important feature to notice. Perhaps, if I say the western quarter is generally higher than the eastern, a clearer idea will be formed of this district than by any detailed description I could give. For drainage purposes Triplicane may be considered to be a flat about 11 feet above the datum line. Saint Thomè is the half of a little hill cut through the crest by the sea. The ground falls on all sides except towards the east, where it is abruptly terminated by a sandy cliff. The top of the hill is 21 feet, and the bottom from 6 to 10 feet above mean sea level. In this division, the strata are partly of sand and partly of clay. Water is found sometimes above and sometimes below mean sea level.

Drainage Outfalls.

The natural drainage outfalls of Madras are the Rivers Cooum and Adyar, Cochrane's Canal and the Sea.

The River Cooum.

The Cooum, which flows in a serpentine course through the heart of the town, may be considered an extensive tank. The bar at the river's mouth is the bund of this tank, and the water, when only at mean sea level, extends more than 3 miles inland

or nearly up to the College Bridge. From January to October the river has no outlet to the sea. It is only during the monsoon, and not always then even, that the bar is open. During the earlier months of the year the water stands at about mean sea level, but it falls gradually during the hot weather to 1½ feet below the datum line, unless there is rain in the interval. The level of the river is not affected by the tides of the sea. The heaviest monsoon does not produce a sufficiently strong current to scour the bed of the Cooum effectually. At present this river forms a large cesspool for the districts of Vepery, Egmore, Chintadrapett and part of Triplicane, all of which drain into it. Owing to the constant flow of sewage into the Cooum, and to the stagnation of the water, so large a quantity of solid filth has accumulated that the bed of the river is raised considerably above its natural level. Strictly speaking, the Cooum, for the last 3 miles of its length, has no fall at all. In fact, if anything, the bed slopes in an opposite direction to the course of the stream. The large drain near Government House Bridge and the main sewer of Vepery near Chintadrapett Bridge have both discharged such a quantity of filth that the bed of the river between these points is actually higher than it is for the previous mile. During the monsoon the water escapes only because the river rises above the bar and forces a breach through it. It will thus be seen that, practically, the Cooum has no outfall at all. To attempt, therefore, to convert it into a sewer is simply to make it a cesspool.

The River Adyar.

The Adyar, which forms the southern boundary of Madras, is really a smaller river than the Cooum, but it widens so considerably before reaching the sea that its waters cover a much larger area, and at its mouth it forms a small lake. Like the Cooum it has no outlet to the sea, except for a short time during the north-east monsoon. It is even less adapted for a drainage outfall than the Cooum.

Cochrane's Canal.

Cochrane's Canal runs in a northerly direction from the Cooum to beyond the limits of Madras. At present it is the cesspool for the western quarter of Black Town which discharges its sewage into it. As there is no current to carry away the solid matter, the bed of the Canal, like that of the Cooum, is higher than its original level.

The Sea Coast.

Madras has 9 miles of sea-coast. The Beach throughout is flat and sandy. For the first half mile from the shore the bed of the sea slopes from 0 to about 7 fathoms or 42 feet in depth. After this the slope becomes very gradual, for, at the distance of $3\frac{1}{2}$ miles from the shore, the depth is only about $10\frac{1}{2}$ fathoms or 63 feet.

Tides.

The difference of level between high and low tide is about 3 feet only, and high and low water mark are taken in Madras at about $1\frac{1}{2}$ feet above and below mean sea level which is invariably ascertained from Colonel DeHavilland's bench-mark spoken of before.*

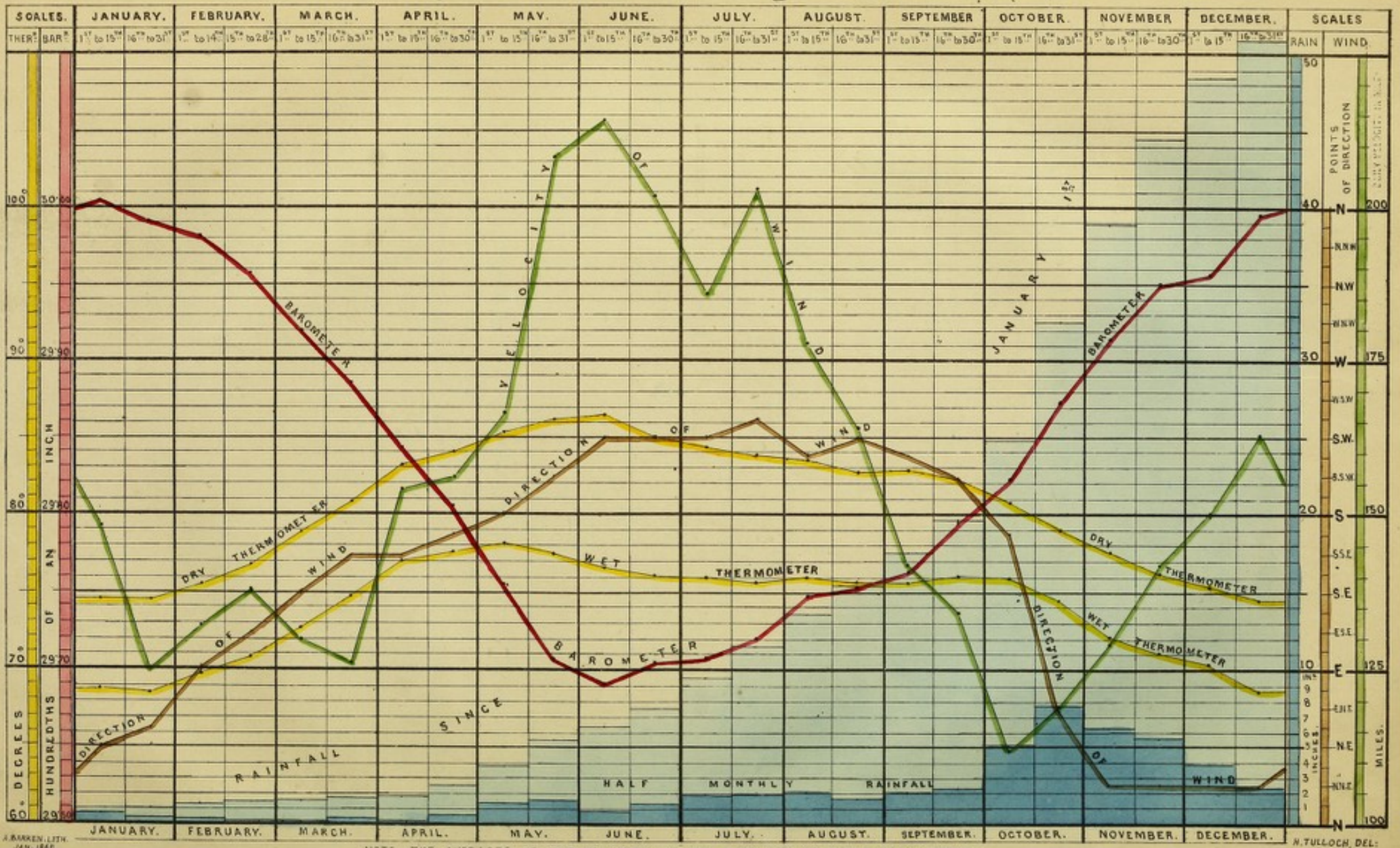
Sea Currents

The two principal currents along the shore of Madras both flow in a direction parallel to the coast. The first, or that which flows from the north southwards, usually sets in about the middle of October, and continues to flow till February, or till such time as the "long shore" winds begin to blow, when the second current sets in and flows from the south northward. This current ceases about August, when variable currents and calms set in and continue till the burst of the N. E. monsoon in the middle of October. The two principal currents, following as they do the course of the winds, must, no doubt, be caused by them. If the wind, therefore, is the chief cause of the currents along the coast of Madras, I think accurate observations would prove that the currents which prevail between August and October have a

* Although the correctness of Colonel DeHavilland's "mean sea level" bench-mark has never been established by any official observations since 1821, there are many proofs that it is sufficiently true for all practical purposes. The tide guage, now in course of construction, will not be completed in time to admit of my making use of the information to be obtained from it.

Madras Drainage.

Half Monthly Averages of 20 Years Meteorological Observations at Madras.



NOTE.—THE AVERAGES OF THE VELOCITY OF THE WIND ARE OF THREE YEARS ONLY.

tendency to flow in nearly the same direction as that which prevails from February to August. The only difference between the winds at the two periods is that there is more westing in those which blow from August to October.* The velocity of the two principal currents at their full strength is computed at 3 miles per hour.†

The general characteristics of the climate of Madras may be ascertained from the accompanying diagram.‡

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* Vide "Diagram showing the number of days in every month of the year the Wind blows in Madras from each point of the compass," which faces page of this Report.

† For all the facts respecting the depth and currents of the sea, I am indebted to Captain H. D. E. Dalrymple, Master Attendant, who has most kindly furnished me with the information I required.

‡ I have thought it better to give the meteorological facts by "projection" than in a table, as a comparison between the phenomena at different times can be much more easily made in the one case than in the other. For every meteorological fact used by me I am indebted to N. R. Pogson, Esq., Government Astronomer, without whose help, which was most willingly given, this Report would have been very incomplete.

CHAPTER II.

THE TOWN OF MADRAS.

Population of Madras.

THE population of Madras, according to the last statement drawn up by the Assessor to the Municipal Commissioners, is tabulated below.

No. of Drainage Division.	Position of each Drainage Division.	Important Districts comprised in each Drainage Division.	No. of Houses in each Drainage Division.	Population.	Average Number of souls to a House.
1	North of the Railway and east of the Canal,	Royapooram. Tondiarpett.	3,433	70,934	20·7
2	South of the Railway, east of the Canal and north of the Cooum,	Black Town. Fort St. George	12,363	149,004	12
3	West of the Canal and north of the Cooum,	Pursewakum. Vepery. Egmore. Elemboor.	5,899	57,244	9·7
4	South of the Cooum.	Chintadrapett. Triplicane. Royapett. St Thomè.	10,915	150,589	13·8
		Total...	32,610	427,771	13·1

In London the density of the population, with reference to the houses, is about 5. A Madras dwelling, therefore, contains more than $2\frac{1}{2}$ times the number of people which a London house does. The density of the population of the northern portion of Madras (20·7) is extraordinary, being more than four times that of London.*

* Even this is rivalled by some of the villages, such, for instance, as Royapett which has a population of 19,210, and only 620 houses,—the density being nearly 31. Is it possible that a population of nearly *twenty thousand* can be living at the rate of 31 in a dwelling—and *such dwellings?* And if this is the *average* density over the entire village, how many men, women, and children must there be in some of the houses? It is not surprising that cholera should be endemic in Madras.

Native dwellings.

A native dwelling in Madras usually consists of one or more open courtyards, each enclosed on all sides by a terraced or tiled building. There are sometimes as many as five of these courtyards running back from the street. Both the buildings and the courtyards almost invariably slope towards the entrance, and their floors are generally raised above the surface of the road--in some streets not more than a foot; in others as much as 4 or 5 feet. These facts are very important for the purposes of this project, and will be referred to when the question of house-drainage is treated.

Water Supply.

The greater quantity of the water used by the inhabitants is drawn from wells built in one or more of the courtyards. When there is one well only, it is usually in the back courtyard. All natives who can afford it buy their drinking water, which is usually brought from a distance. For all other but drinking purposes, the water in the wells is made to answer. On account of the abundance of water in the Madras wells, much more is used than might be supposed. Almost all the wells in or near the thickly populated parts of the town contain more or less organic matter. This is entirely due to the sewage of the town escaping first through the badly constructed drains in the streets, and then through the sub-soils to the stratum of sand which holds the present water-supply of Madras. Sooner or later, this water-supply must become so impregnated with the sewage as to be rendered unfit for use. In many places this has already occurred, for the wells are as offensive as cesspools, and in consequence have been abandoned by the people.* These facts, which have been brought to light by the numerous borings I have made in all parts of the town, may be relied on by Government. I bring them thus prominently to their notice, in order to show

* Every well in the town should be closed as soon as it is disused, for foul water never ceases to give off poisonous gases, and it becomes more foul the longer it is kept.

the necessity for a system of water-tight pipe-drains and sewers, which, while it relieves the dwellings of all liquid refuse, will, at the same time, preserve the water-supply of Madras from contamination.*

Present system of house drainage.

The greater portion of the water drawn from the wells by the inhabitants is used for washing and bathing, and generally in the back courtyard, where also the cleaning of the pots and pans takes place. All the refuse water, both from the yards and from the cook-rooms, is discharged by an open channel (about 4 or 6 inches square) into the street drain. There is a privy in each house, usually on one side of the back court-yard. It consists of seats formed by low walls of brick in chunam between which the ordure falls, while the urine escapes into the same open channel which conveys away the waste water from the dwellings. All solid filth is removed by scavengers, who call at each house once or twice in the day, and deposit it in the Municipal carts which convey it away from the precincts of the town. As a rule, there are no cess-pits in the dwellings. The house-drain for all liquid refuse has its outlet in the front of the dwelling, where it drops its contents into an open drain of a rectangular section (about 15

* In some places I met with pure liquid sewage. There is no mistake about this, for the smell was so overpowering as to leave no room for doubt in the matter. As a general rule, a well dug in virgin soil in Madras will produce good water—provided that it is sufficiently far removed from dwellings. By good water I mean water not impregnated with sewage. Of a town situated, as Madras is, on the sea coast, and with a sub-soil of sand, it would be impossible, unless a very great number of borings were made, to say where the water would or would not be slightly brackish. Wherever good water occurs, the sand is uncoloured, sharp and sweet, while, in all instances in which sewage has percolated through the upper strata, the sand beneath is coloured dark with organic matter, and is more or less offensive to taste and smell. It is remarkable that some wells dug on the *very margin* of densely populated neighbourhoods produced good water. A little consideration will explain this peculiarity. The chief supply of water being drawn by the inhabitants from wells situated *in* the town, the "pull" has been *from* the margin all round *to* the centre. No sewage, therefore, has flowed out of the town into these wells on the outskirts.

inches by 1 foot) running along the side of the street. This, again, is connected further on with another drain of a similar kind, but of larger dimensions, and so on, until the last discharges itself into a sewer which lies a few feet below the surface of the ground. Both the street-drains and the sewers are built of ordinary bricks set in shell lime mortar. They are as porous as they can be, and smell most offensively. Having no proper slope, they are daily choked up with filth, the removal of which is effected by manual labour only. It is for the cleansing of these drains, which are a receptacle for all the solid filth of the streets, that so large an establishment of scavengers is employed by the Municipal Department. Present street drains.

At present the main sewers of Madras have three outfalls— the Sea, the River Cooum and the Canal. Black Town drains into the sea, except the small portion of it lying to the west of Salay Street which drains into the Canal. Vepery, Egmore, Chintadrapett and part of Triplicane drain into the Cooum. The main sewer of Black Town has its outfall at the north-east angle of the Fort. This, being the largest, is the most offensive sewer in Madras. The main sewer of Vepery discharges its contents into the Cooum near Chintadrapett Bridge, where it has deposited a great quantity of filth in the bed of the river. The mouth of the main sewer of Chintadrapett and Triplicane is near Government House Bridge, where an effect similar to that of the Vepery sewer has been produced. Besides these main channels which discharge both sewage and flood-waters, there are numerous small drains which have their outlets in the Cooum and the Canal. Present main sewers.

It must not be supposed from the above that all the sewage of the Town is discharged at one or other of these outfalls. Nothing could be further from the fact. There are both individual streets and extensive areas in each neighbourhood which have no outlet at all, and where the sewage stands in Parts of the Town wholly undrained.

open trenches round the dwellings, and stagnates from day to day, and from month to month. The only cleansing process that ever takes place is that caused by a heavy fall of rain, when the water overflows the sides of the trenches, and, in seeking an outfall, carries away some portion of the filth with it.

CHAPTER III.

DRY CONSERVANCY.

In the present state of the question of conservancy, a report on a proposal to cleanse an Indian Town by means of sewers would be very incomplete, if it did not enter into a full discussion of the new theories which have lately been started regarding dry conservancy.

Any organic substance exposed to the air is soon destroyed by the oxygen of the atmosphere. The moisture is evaporated, and the body converted into new compounds of a more permanent form than those of which it was originally composed. While the body is in this state of decomposition, offensive gases are given off, but when it has taken its more permanent form, the evolution of the gases usually ceases. If, however, water be poured on the substance, or it be allowed to lie in water, a second process of decomposition takes place, which again ceases when all the water has been evaporated. This may be repeated many times.

The noxious smells about cook-rooms and privies arise, to a great extent, from the decomposition of organic matter promoted, in the first instance, by the action of the atmosphere, but continued by that of water. The nuisance caused by allowing refuse vegetables to lie in the streets and dry by the heat of the sun is harmless, compared with the effect that is produced by throwing them into the water lying in the drain close by.

Hitherto, in privies, all excrementitious matters have been removed by aid of water. It is now demonstrated that water can be dispensed with, and that privies can be kept much

more wholesome without it. It is urged that certain substances which have the power of preventing the exhalation of foul gases should take the place of water. Of these, charcoal, ashes and clay are the most important. It is found that they rapidly absorb the moisture in excrement, and thus at once deprive it in a measure of its offensive properties. But this is not all. Even the bricks and chunam with which the walls and floors of privies are built are now objected to, inasmuch as they soon become saturated with urine or refuse water and retain for a very long time the power of exhaling noxious odours. It is proposed, therefore, either to dispense with these materials altogether by building with clay which is a deodorizer, or, at all events, to cover them with some substance, such as tar or asphalte, which does not absorb moisture—On these broad principles dry conservancy is based.

Dr. Hathaway's system of dry conservancy.

The best account of the new system is given in the Punjaub Sanitary Report for 1862, by the originator, Doctor Hathaway, of the Bengal Medical Service. The following is an extract from this Report:

"The latrines used in the Punjaub Jails are perfectly free from any effluvium whatever, and the essential points in which they differ from the majority of those constructed for Military use are as follows:—

A. The absence of all masonry or pucca work containing lime cement.

B. The prohibition of all cesspools or reservoirs, and all drains or pipes, whether closed or open, leading in or out of the latrine or urinary.

C. The prohibition of water being used to flush the ground or flooring, which is to be kept perfectly dry.

D. The flooring being of earth, (instead of pucca masonry or stone) on which dry sand to the depth of 4 inches over a layer of well rammed clay is strewed, and the portable vessels for the reception of both fluid and solid refuse matter being deposited on the sand.

E. The immediate removal of all refuse matter from the latrine itself, and the careful burial every evening in trenches dug for the purpose.

F. The abolition of the practice of sprinkling powdered lime in the urinaries and latrines, or in any other spot."

The other points to be attended to are—to build urinals separate from latrines—to provide thorough ventilation for both—to make all the seats in the latrines of wood and the pans of iron or earthenware—to provide a large iron receptacle with a close fitting lid in the rear of each latrine, into which the contents of the pans are to be emptied as fast as the latter are used—to keep the seats, floor, and vessels scrupulously clean—and to use charcoal and wood-ashes as disinfectors in place of lime.

Suggested improvements on Doctor Hathaway's system.

Such are the main features of dry conservancy on Doctor Hathaway's principle. It is impossible to call in question the great success which has attended its introduction. The privies are clean and free from all offensive smell, and have met the entire approval of the authorities in Bengal. Like every thing else, however, of the kind, the dry system is still capable of improvement. Some important modifications, therefore, have already been made. The chief of these is the use of clay as a disinfector in place of charcoal or wood-ashes. The advantages of clay are—that it is easily procurable and exceedingly cheap—that in a dry state it is one of the best disinfectors for excrementitious matters yet discovered—and that after use it possesses a high value as a fertilizing manure. Another modification is the use of tar or asphalte for the floors and the walls of the privies. This has not, however, the advantage of cheapness. The last improvement yet made consists in the separation of the urine from the fæces. This idea originated with Doctor Thudichum, a physician in England.

The subject of dry conservancy is now attracting consider-

Opinions of the advocates of Universal Dry Conservancy

able attention in England, and, from what can be gathered, still more attention in India, to which country it is much better suited. The great argument in favour of it is based on the fact that the most valuable manure known to man, viz., urine, will be saved for agricultural purposes. If the manured clay should hereafter possess a high commercial value, the argument will be all the stronger. So far as the application of dry conservancy to latrines is concerned, I am entirely in accord with the advocates of this system—provided that the cost of it is not to be borne by the people who could never, as will be shown presently, afford to pay for it. But some of these advocates, in the heat of the excitement caused by a new and very important discovery, will not look at the question except from one point of view. The consequence is, that the most absurd and extraordinary statements are made by them as to the efficacy of the new principles, and as to the wonderful application that may be made of them. "The old system of drainage by sewers is obsolete—is a quarter of a century behind the age—is not worthy the science of the day. Dry conservancy absolutely revolutionizes the subject of drainage. We must begin *ab initio*—the great sanitary problem of the day has been solved. We are to have no more sewers and no nuisances. The town is to be cleansed on new principles, and at little or no cost to the inhabitants."

If it should be thought that this is an exaggerated account of the effect expected to be produced by the adoption of dry conservancy, the following extracts will prove that it is not. Speaking of the application of the dry system to large cities (and more especially to London) in which water drainage exists, and where it might naturally be supposed that the subversion of the present system of sewers would be attended with considerable expense, the Reverend H. Moule says—

"In the establishment of the earth sewage system no public works are required, whilst the three and a half millions being spent by the

Metropolitan Board for the greater efficiency of the public works now existing, would have defrayed double the cost of all private works of the earth sewage system for London; and the manure saved, instead of wasted, would, on the very lowest estimate, have produced a clear income of £50,000 a year.*

The same idea has been repeated in other words by a gentleman in Madras, who has now for some years interested himself in the question of sanitary reform. In a pamphlet called "The Cleansing of Towns," written by Doctor Cornish, Assistant Surgeon, and Secretary to the Director General of the Medical Department, he says—

"The greatest advantage of all would be the doing away with the necessity for costly drainage works,"†—and again, "Before spending some half a million of money in a system of sewers for Madras, it may be well perhaps for the rate-payers, who will ultimately have to defray the cost of the 'improvement,' to enquire whether for an expenditure of one-twentieth part of the money it may not be possible to make our chief city a model of cleanliness, and its excreta so valuable, that the cost of collection should be a mere trifle in the Municipal expenditure."‡

The fallacy of universal dry conservancy.

It will thus be seen that both the Reverend H. Moule and Dr. Cornish consider dry conservancy sufficient of itself to correct all the evils of a town,—those at least which arise from defective drainage. The picture has been painted in such bright colours, and has so greatly pleased the painters, that they have not cared to enquire whether it is true to nature. But the argument for dry conservancy, put in few words and cleared of everything which in any way keeps the real point at issue from view, may be stated thus—"because dry conservancy is the best system for privies; therefore it

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* Vide Page 448 of Volume XI of the "Journal of the Society of Arts," for May 15, 1863. Mr. Moule subsequently disclaimed any intention to apply dry conservancy except to towns which were wholly undrained.

† Vide Page 19 of Dr. Cornish's Pamphlet.

‡ Vide Page 23 of the same Pamphlet.

is the best system for towns." The fallacy arises from forgetting that in the one case, *i. e.*, in privies, excrementitious matters only are dealt with, and in the other that the same excrementitious matters form but an inappreciable amount of the filth to be removed. It is just as if a man should attempt to clean out the dust-holes of London by crushing the bones to be found in them, and then carrying away the powder as manure. Of course, he could urge that he had taken away the foulest portion of the refuse and had utilized it for agricultural purposes, and this would be perfectly true. But it would be equally true that he had left nearly all the filth behind. And this is a case exactly parallel with that of dry conservancy, when it is insisted that this system must *supersede* that of sewers. The advocates of the former keep urging that all the urine and fæces will be carried away and converted into manure, and, of course, nobody can deny the proposition which is perfectly patent. But it is also true that almost all the sewage will be left behind. In a word, though urine and fæces are undoubtedly the most offensive part of town sewage, yet in bulk they do not amount (as in the case of London for instance) to more than $\frac{1}{200}$th of the whole. This is so easily proved, that it can escape the observation only of persons so wedded to a new theory, as to be unable to look adverse facts in the face, but it explains at the same time why those who have to remove the sewage in England do not consider the extravagant proposition to do away with sewers worth refuting.

Proportion of excrement to liquid sewage

The average of the returns of the Metropolitan Water Companies shews that the quantity of water used in London per head of the population is 44 gallons=440 lbs. The average quantity of excrementitious matter voided by each individual may be taken at 2 lbs. of urine* and $\frac{1}{4}$ lb. of fæces†,

* Vide Page 679 of Fownes' Manual of Chemistry, 7th edition.

† According to Baron Liebig.

or together to 2¼ lbs. This is equivalent to $\frac{2\frac{1}{4}}{440}$ = very little more than $\frac{1}{200}$th of the waste water. Suppose, however, that in Madras, 5 gallons only or 50 lbs. of water are used per head of the population, then the excrementitious matter will be $\frac{2\frac{1}{4}}{50}$ = not *one-twentieth* of the water. Mr. Fraser, C. E., informs me that he proposes to supply 20 gallons or 200 lbs. of water per head of the population. If this is done, the excrementitious matters will be very little more than *one-hundredth* of the waste water to be removed. The proportion of night-soil to liquid sewage in Bombay is calculated at 1 to 775.*

Refuse water admitted to be only less offensive than excrement.

It might, however, be supposed, that, in answer to all this, it would be contended that, if sewage were deprived of excrementitious matters, it would not be offensive, and might lie harmless in the drains. This certainly would be an extraordinary argument to urge with any one acquainted with the mode of conservancy adopted in Madras, where already almost all the fæcal matter is removed by the Municipal carts, and the smell in the streets is, nevertheless, perfectly sickening. But still it would be taking the bull by the horns. The advocates of the dry system, however, take up no such position. On the contrary, they urge with all the force they can that *water! water!* is the chief cause of the evils in privies—prohibit its use, and the privies will be clean and wholesome. Indeed, they insist that waste water from dwellings is only less offensive than *excrement itself*. The following extract from Dr. Cornish's pamphlet will shew that I do not misrepresent the views of these gentlemen—

"In tropical countries the putrefactive process, *when water is present*, proceeds with a truly wonderful rapidity. Not only do animal excretions

* Vide Page 32 of "Correspondence on the subject of the Drainage of Bombay, 1863."

decompose with great speed, generating poisonous compounds to pollute the atmosphere, but common house-sweepings, cook-room refuse, &c., when mixed with water, become in a very short time an intolerable nuisance. Even the waste water from bath-rooms, if retained for a few hours in a cesspool or reservoir, will be almost as offensive as excrementitious matters themselves."*

Now, is it not strange that the same people who see so clearly the danger of allowing waste water to stagnate and poison the air, will not admit the necessity of making provision for its removal. The project now submitted to Government, like all drainage projects, has for its object the removal of this very waste water without retaining it in cesspools or reservoirs. When it is shown that this can be done effectually in all towns by a cheaper method than that of sewers, of course that method should and will be adopted, but until then there is little doubt that the system of drainage by sewers will prevail in India as in Europe.

Dry conservancy does not provide for the removal of waste water.

It will thus be seen, that, in advocating the universal application of dry conservancy, it has been entirely forgotten that the use of water, which should be *prohibited* in privies, should be *encouraged* in houses. By strict supervision, water may be excluded from the former, but, so long as we are human, it must be used in the preparation of our food, and for the cleansing of our persons and our dwellings. To those who say—"no public works are required," "do away with your sewers and adopt the dry system," is it not natural, under all the circumstances mentioned above, to reply,—"in that case, what shall we do with our waste water, for you yourselves say it is only less offensive than excrement?" The advocates for the universal application of dry conservancy are bound to answer this question before they make the extravagant proposal to cleanse a town solely by building model privies.

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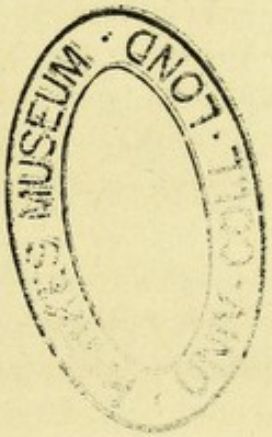
* Vide Page 6 of Dr. Cornish's Pamphlet.

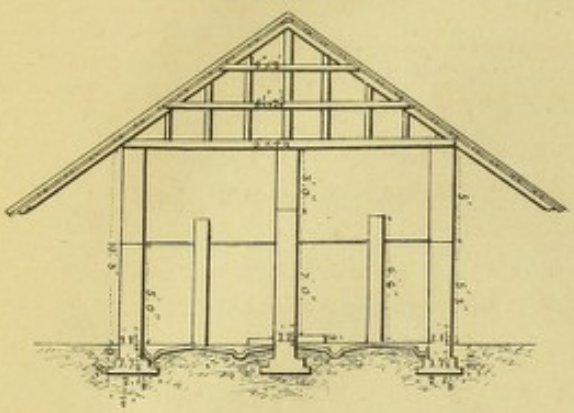

BRIT. MUSEUM · LOND.

PLAN OF A LATRINE.

DESIGNED FOR THE USE OF NATIVES,

AND IN WHICH THE EXCRETIONS CAN BE SEPARATELY COLLECTED.

Section thro' A.B.



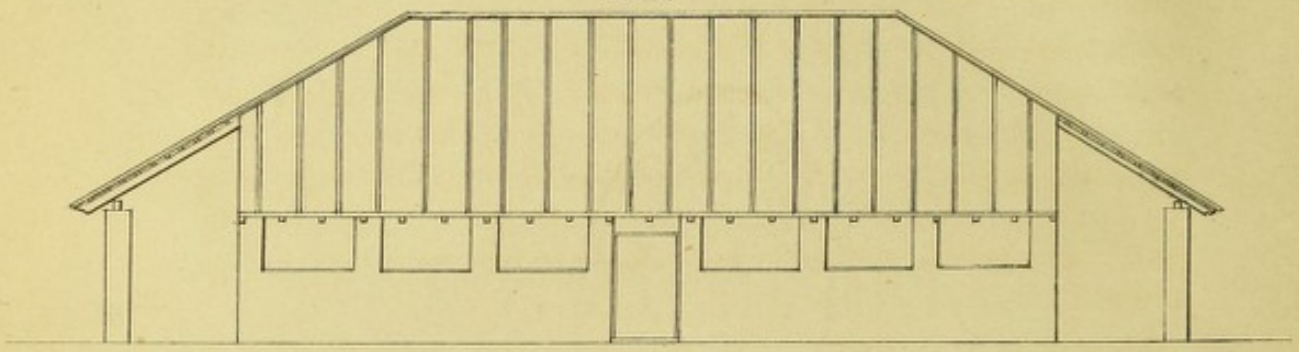
ESTIMATE OF LATRINE AS GIVEN BY R. ANDERSON ESQ.ᴿᴱ
ASS.ᵀ CHIEF ENGINEER, MADRAS RAILWAY.

Excavation	Cub. yards	54	-/4/-	13	8	-
Brickwork	do	65	6/-/-	390	-	-
Plastering	Square	20	6/-/-	120	-	-
Flooring with asphalte	"	14	23/-/-	322	-	-
Stone work	Cub foot	36	1/-/-	36	-	-
Teak timber	"	230	3/8/-	455	-	-
- - - reapers	per hundred lineal feet	1800	3/8/-	90	-	-
Zinc sheeting	Tons	1 1/3	524/-/-	698	10	8
Lead pipe	Lin. foot	28	1/8/-	42	-	-
Contingencies				216	13	4
			Rupees	2384	-	-

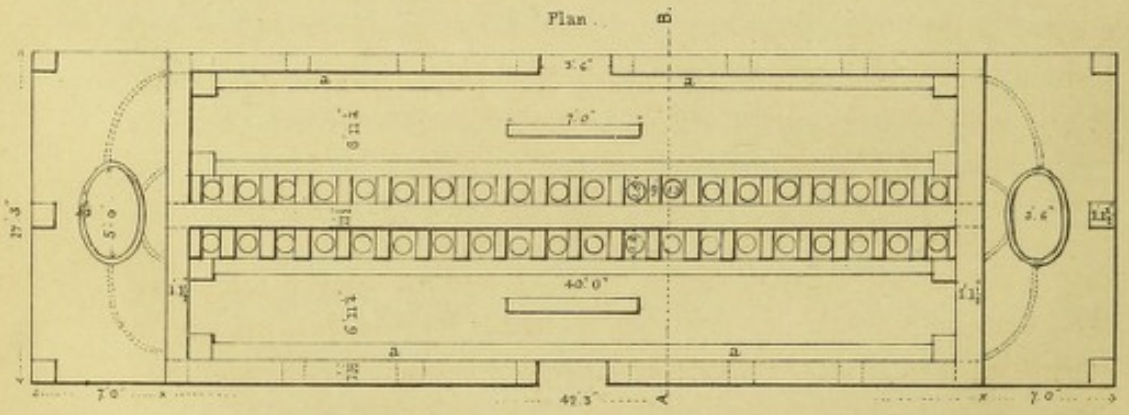
REFERENCE -

a. Urinal.

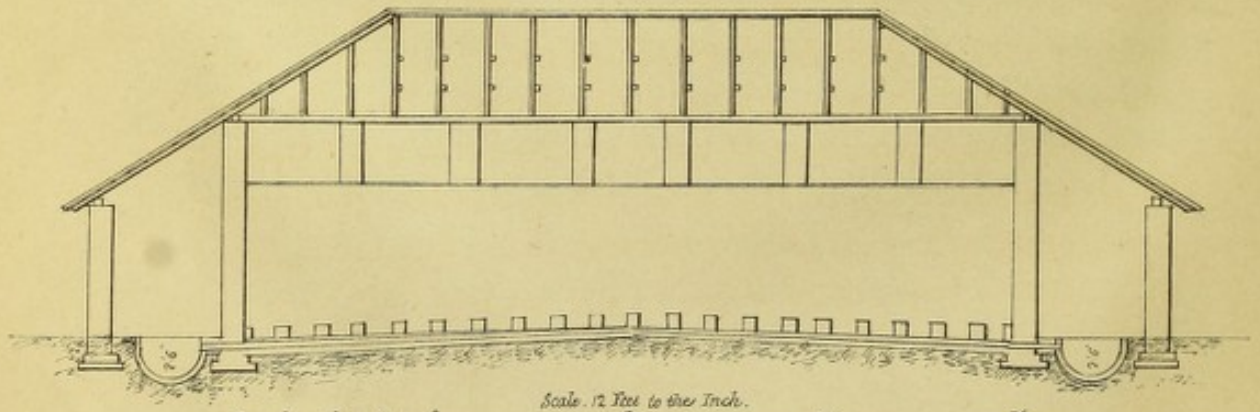
Elevation.



Plan.



Longitudinal Section.



Scale. 12 Feet to the Inch.

0 3 6 9 12 24 36 feet.

G. Winchester Lith.ʳ Madras.

Copied from the original in Doctor Cornish's Pamphlet. "The Cleansing of Towns.

But in order that Government may understand all that is proposed to be done in Madras, I will try to put the system of dry conservancy as a whole before them. Public privies of an improved design are to be built in all parts of the town and at such convenient distances apart as shall induce the inhabitants to use them.

The dry system for towns as proposed by Dr. Cornish.

"One side of the building is for males, and the other for females, twenty of each might be accommodated at one time in the privy. The urine, voided into a channel against one wall of the building drains along an asphalted gutter, (the whole of the interior, floor and walls is to be asphalted), and after being filtered through a movable screen containing coarsely powdered charcoal, is finally received into an asphalted reservoir outside, which reservoir is to be nearly filled every day with dry earth, to allow of the urine being absorbed and subsequently carted away without decomposition or offence. The object of the filtration through charcoal is to remove the mucus of the urine, by which arrangement it will not begin to decompose for a period of 24 hours or more.

"In the privies, the following arrangement is suggested. In the space allotted to each person the toty will keep a flat, saucer-shaped chatty painted or soaked in coal tar, and well dried previous to use, to receive the solid excrement. These chatties should always contain a little dry earth or wood-ashes, and after use the evacuation should be immediately covered with a small quantity of *wood-ashes*, kept in readiness for the purpose within the enclosure, and the whole removed to the shed outside, where the chatty should be emptied, and the mixed ashes and fæcal matter put into an iron tub or basket for removal. It will be observed in the plan, that separate provision is made for the reception of the urine passed during defecation, in an asphalted channel, which conveys it to the urine reservoir outside."*

It is expected that the excrementitious matter, after being converted into manure, will be gladly removed by contractors who will find it pay them to use it on the lands about Madras. It is moreover considered that, on account of the highly

* Vide Page 16 of Dr. Cornish's Pamphlet.

deodorizing properties of clay, no nuisance will be caused by the construction of the latrines even in the heart of the town, and that the removal of the manure through the streets will give no offence.

The success of the scheme entirely dependent on a universal use being made of the latrines.

It is evident, on a *primâ facie* view of the matter, that the entire success of the scheme will depend on a universal use being made of the latrines. Because, if some people use them and others do not, we shall have both the expense of the new system and the nuisance of the old. It is not shown, though, how this end is proposed to be secured. Whether the people will be compelled by law to frequent the public privies, or whether the use of them is to be entirely voluntary. It would not much signify, however, if a dozen laws were passed on the subject, for the State, having no control over the individual in his dwelling, could not prevent his evading the law in it if he chose to do so.

Dry conservancy for women.

We will assume, therefore, that it is intended that the question should be decided by the common sense of each individual. But common sense appears to me to be against the universal use of public latrines, so far at least as women are concerned. Can it be expected that any respectable man will permit his wife or his daughters to leave the privacy of their home—to walk, say, 150 yards in dry and wet weather along a public street to a public place for *such a purpose*—to mix there with perfect strangers—and to perform such a duty in their very presence. Yet, if the women as well as the men did not use the privies, what measure of success would attend the introduction of dry conservancy. The advocates of this system may point to the fact that the existing public latrines are made use of by women, which is perfectly true; but it is by women of the very lowest classes, and by such of them only as have no backyard or enclosure of any kind to resort to. And even these women are driven to the

public privies only by the strict supervision of the Police. Instead, therefore, of encouraging what every one will admit is a proper sense of decency, dry conservancy proposes to lower all classes to the same degrading level. Surely this is a backward step in civilization. Let it be remembered, too, that children and young girls are to be subjected to this public ordeal. To what a state of morality must this lead?

Even in England, where every water-closet at the Railway Stations is a separate room and has a lock and a key in the door, the prejudice even among men against it is so strong that nothing but the greatest necessity will induce them to use it. I am aware that this prejudice arises in a great measure from the fact that infectious diseases are easily propagated by the water-closet system, but it arises also from other causes. In spite, too, of every care that might be taken in the public latrines in Madras, it would be impossible to prevent some of these infectious diseases spreading amongst the people. They must all wash at one and the same place. It would not be possible to have large tanks in the heart of the town, and, if these were erected, the cost of the system would be enormous, as will be shown presently.

How will the sick be provided for.

Besides, how will it be possible to arrange for the wants of the sick, who will not be able to leave their dwellings, and who, at the rate of five sick in every hundred of the population, will amount in number to $\left(\frac{430{,}000 \times 5}{100} =\right)$ 21,500 souls—producing daily more than 21 tons of excrementitious matter. Where, too, will the line be drawn amongst the community as to the use of the latrines? If natives *must* use them, so must East Indians, and so must Europeans. There cannot be one law for the native and another for the European. And will Europeans and East Indians submit to such an arrangement? Will they sit on the same seats with natives, and in the same manner? If not, it will be necessary to

provide separate latrines for the different races, and this again will add to the cost.

The difficulty of carrying out dry conservancy in wet weather.

In rainy weather, moreover, how will it be possible to induce the people to go to the privies. This is the very time, too, when the offensiveness of urine and fæces will be greatest. The difficulty of carrying out dry conservancy in wet weather has been partly foreseen by Doctor Cornish, but not entirely provided against. He says "In wet weather a supply of dried earth should be kept ready prepared *under cover*."* This is all very well so far as the clay is concerned, but what will be the use of it if people do not frequent the latrines at that time.

The necessity of constant supervision one of the great objections to dry conservancy.

One great objection to dry conservancy has already been brought to the notice of Government. This is the liability of all public latrines to become mere cesspits, unless constant supervision is exercised over the toties employed in them. Doctor Chipperfield, in his report on the Railway Stations, says—

> "I fear that great difficulty will be experienced in causing native officials to carry out effectual conservancy, if supervision be left entirely to them. Certainly, the native Station Masters are very intelligent men; but as Doctor Mackay remarks, 'being natives themselves, they are not alive to the injurious consequences of the neglect of sanitation.'"

Thus, two Medical gentlemen suggest the necessity of European superintendence, the cost of which will be very heavy. A system of conservancy which requires unremitting attention and becomes a nuisance by the least neglect, is ill-suited to a large population. As a proof of this, I need only recal to the recollection of Government the outbreak of cholera at the Railway Stations.

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* Vide Page 18 of Dr. Cornish's Pamphlet.

The difference between dry conservancy in small establishments and in towns.

In advocating universal dry conservancy, people are too apt to be led away by the success which, *under certain conditions*, has attended its introduction into India. Whenever it has been tried on a limited scale, as, for instance, in Barracks, Jails, Hospitals, &c., its success has been complete. But the reason is so obvious, that it is strange it should be so often overlooked. If Government have a number of troops, or prisoners, or invalids whom they can easily keep under discipline, every individual can be compelled to make use of the latrine. The very fact of a man entering a hospital is an admission on his part that he is willing to submit to the regulations of the place. But the question assumes a different aspect altogether when Government have to deal with a mixed population of half a million men, women, and children, scattered over many square miles of country—living in all kinds of houses—and over whom, as soon as they are within their own doors, Government can exercise no control whatever. How can a universal use of public privies be enforced under such circumstances.

The cheapness of dry conservancy, a delusion.

But Dr. Cornish claims one great advantage for universal dry conservancy, viz., that it is much cheaper than the sewer system. This is certainly the most unfortunate mistake that has yet been made by the advocates of the new theory, and the one which will tend to damage it more than anything else. He says :—

"Before spending some half a million of money in a system of sewers for Madras, it may be well perhaps for the rate-payers, who will ultimately have to defray the cost of the 'improvement,' to enquire whether for an expenditure of one-twentieth part of the money it may not be possible to make our chief city a model of cleanliness, and its excreta so valuable, that the cost of collection should be a mere trifle in the Municipal expenditure."*

It will thus be seen that $2\frac{1}{2}$ lacs of rupees is the sum set down for cleansing Madras thoroughly according to the new

* Vide Page 23 of Dr. Cornish's Pamphlet.

principles. It has always been maintained by the Engineering profession, that, whatever objections might be raised to the sewer system, it was the *cheapest* means known of disposing of sewage. A sewer, once built properly, will, with occasional trifling repairs, last for centuries. An inconceivable quantity of water may be passed through it. It will work as well in the night as in the day. With fair play the supervision required is most trifling. It is necessary, therefore, to ascertain if dry conservancy is cheaper.

Dr. Cornish says :—

The number of latrines required.

"A large number of latrines and public urinals are wanted, and these must cost some money. Those at present in use might I think in many instances be altered to suit the new system. The conservancy establishment will also have to be enlarged."*

Now, first, as to the number of latrines. Unless they are aware of it, Government will no doubt be surprised to learn that already, while there is no attempt at a *system* of dry conservancy, the Municipal Commissioners have built nearly a *hundred* latrines.† These are not sufficient for even the lowest classes of the people. How many, therefore, will be required for the entire population ? Government have ordered that 8 seats shall be provided for every Company of European Soldiers. This is equivalent to nearly 10 per cent. I will suppose, however, that 6 seats only will be sufficient for every hundred souls. The total number of seats required for Madras will be:— $\frac{430{,}000 \times 6}{100} = 25{,}800$. Each latrine, according to Dr. Cornish's design, (vide drawing), is to hold 40 seats. Therefore, the total number of latrines required will be :— $\frac{25{,}800}{40} = 645$ latrines.

The cost of the latrines.

Each new latrine, according to Doctor Cornish's estimate,

* Vide Page 23 of Dr. Cornish's Pamphlet.

† The exact number is 88.

(vide drawing), is to cost 2,384 Rs. Suppose that each of the present latrines could be altered to his design for 2,000 Rs.* so that there would be a hundred existing when the new scheme was carried out. Then the total cost of all the latrines would be :—

		Rs.	Rs.
100 present latrines	×	2,000	= 2,00,000
545 new do	×	2,384	= 12,99,280
			Rs. 14,99,280

or almost exactly 15 lacs of Rupees.

The number and cost of urinals.

Suppose the same number of urinals, or 645† in all, are required for the town, and that each will cost 400‡ Rs.; then the total cost of the urinals would be:—

645 urinals × 400 Rupees = 2,58,000 Rs.

Number and cost of the sheds.

Of the sheds, Doctor Cornish says—"I premise as a part of the scheme that sheds are to be built, for the reception and storage of dry earth, and for receiving the deposits from the latrines. These sheds might easily be constructed to hold

* From an examination of the latrines now in use, I believe it would be cheaper to erect new latrines than to alter the present ones.

† There ought properly to be double or treble this number, because urine is voided 5 or 6 times as often as fæces.

‡ The urinals must be covered buildings in order to keep out the rain which would otherwise spoil the urine for manure. It may be urged that no urinals should be estimated for, if I take Dr. Cornish's estimate for the latrines, in each of which there is a urinal provided. But it must be remembered that it is he who urges the construction of urinals apart from latrines. In page 19 of his Pamphlet, he puts the following as one of the five great advantages of his plan:—"Public urinals distinct from privies, can be set up in the most convenient situations, and arranged upon this system, and the whole of the fluid excretion thus saved for restoration to the soil." The doing away with urinals in the latrines will effect little or no saving, as they are already as narrow as they can well be. Indeed, I dont think the seats and the urinal could be used at the same time by a number of persons, for there is less than 5 feet of standing room between them, and how could forty people pass and re-pass each other without the greatest confusion in such a small space. I have, however, taken the cost of each urinal at Rupees 400, instead of 500, which I should have taken each at if there had been no urinals in the latrines.

a supply of earth to last for several weeks at a time."* It would undoubtedly be cheapest to have a shed attached to each privy, otherwise the clay would have to be carted unnecessarily far. Suppose a shed could be erected for 500 Rupees,† then the total cost of all the sheds would be :—

645 sheds × 500 Rs. = 3,22,500 Rs.

The extent of the land required for the works.

Each latrine is 56 feet long by about 30 broad. Allow a passage all round 10 feet wide for the cart which is to bring and carry away the clay. Then the area covered by each latrine will be :—

$(56+20)\times(30+20)=3{,}800$ square feet,

or say 4,000 square feet, allowing for the passages from the street to the entrances, and for arrangements being made for the natives to wash themselves, for which there is no provision *in* the latrines, where, according to the new theory, water *must not* be admitted. Then the total area occupied by the new latrines would be :—

4,000 square feet × 545 latrines = 2,180,000 square feet.

Suppose that each urinal with its passages, &c., occupied 500 square feet only. Then the total area of the ground for the urinals would be :—

500 square feet × 645 urinals = 322,500 square feet.

Suppose that each shed, with the passages for the cart and the storing and drying rooms, occupied the same space as a latrine ; then the total area of all the sheds would be :—

4,000 square feet × 645 sheds = 2,580,000 square feet.

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* Vide Page 22 of Dr. Cornish's Pamphlet.

† Doctor Cornish has suggested that the roofs of the privies and urinals, (and therefore also of the sheds one may conclude), might be of leaves ; this would be most objectionable, for all thatch easily catches fire. The risk of having a number of thatched buildings in the heart of the town would be very great. Thatched buildings would be more expensive in the end, as the thatch would require constant renewal.

The total ground taken up by the latrines, urinals, and sheds, will be

	square feet.
Latrines - - -	2,180,000
Urinals - - -	322,500
Sheds - - -	2,580,000
Total...	5,082,500

$$= \frac{\text{5,082,500 sq. ft.}}{\text{(one ground=)2,400 sq. ft.}} = \text{say only 2,117 grounds of land.}$$

Cost of the land.

Land in the heart of the town, where the latrines, urinals, and sheds must be built to be of use, is most expensive.* But suppose that Government could purchase land for, say, 250 Rupees a ground. Then the total cost of all the land would be :—

2,117 grounds × 250 Rupees = 5,29,250 Rupees.

Number of the establishment required.

Of the establishment required for dry conservancy, Doctor Cornish says—"To work a latrine and urinal such as has been briefly described, if in a populous neighbourhood, there would be required two toties constantly on duty, say from 4 A. M. to 10 P. M., and this would necessitate the employment of four persons—two males and two females."† As there would be 645 latrines and the same number of urinals, the total number of toties for both latrines and urinals (assuming that 4 persons could daily look after both a latrine and urinal) would be :—

645 latrines and urinals × 4 toties = 2,580 toties.

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* On the *outskirts* of the thickly populated parts of the town, some land required for the project now submitted has been valued by the Collector's Department at 400 and 350 Rupees per ground. In the heart of the town, land would be much more expensive than this. But I take the low rate of 250 Rupees a ground in order to prevent all controversy on the subject.

† Vide Page 19 of Dr. Cornish's Pamphlet. I learn from the Barrack Master's Department that *four* men and *four* women are required daily for the latrine attached to the Parcherry Barracks, in which there are only 12 seats for men and 12 for women.

Two men at least would be required for each shed, for the toties (two of whom at each latrine would be women) could not attend to the latrines and urinals and also to the sheds, where the drying and storing of clay would need much labour. I do not think the toties could even attend to both the urinals and latrines, for they would be separate buildings, but, however, let this be assumed. The total number of men for the sheds would be :—

645 sheds × 2 men = 1,290 men,

or the total establishment would consist of—

For Latrines	- -	2,580 men & women.
For Sheds	- -	1,290 men.
	Total...	3,870 souls.

Cost of establishment.

Suppose each toty received no more than 3½ Rupees monthly,* which is about as small a sum as any person who had to work for 9 hours in the day (this is what is proposed) could possibly live on. The total monthly cost would be :—

3,870 persons × 3½ Rupees = 13,545 Rs.,

and the total yearly cost :—

13,545 Rupees × 12 months = 1,62,540 Rs.

At the present value of money,† or supposing 5 Rupees yearly to represent a capital of 100 Rupees, the above sum would then represent a capital of :—

1,62,540 Rupees × 20 = 32,50,800 Rs.,

i. e., upwards of 32½ lacs of Rupees.

Cost of removal of manure.

The cost of carting away the excrementitious matter should next be considered. Suppose, as before, that each individual produces 2 lbs. of urine and ¼ lb. of fæces daily, and that (according to the Rev. H. Moule) "one ton of earth or of London

* Each man and each woman employed in the Fort receives 4 Rupees 6 Annas a month, but, as I have no wish to exaggerate the cost, I prefer taking 3½ Rupees monthly as the pay of each toty.

† To simplify the calculation, I have taken this as the present value of money, although Government 5 per cent. paper (while I write) is at 102¼ to 103¼. The cost of my own project is calculated at the same value of money.

clay would be sufficient for 1,000 uses,"* then the total quantity of earth and excrement to be removed daily, (assuming that each individual retired once a day, and that the population was 430,000), would be :—

430 thousand × 1 ton = 430 tons of clay
430,000 souls × 2¼ lbs. = 430 tons of excrement (at least)

Total...860 tons of manure.

A pair of good bullocks may draw in a good cart a load of ½ a ton.† Suppose the manure had to be taken an average distance of two miles, and that each pair of bullocks made 3 journies in the day. Then each pair would remove daily 1½ tons of manure. The number of pairs of bullocks required would be :—

$$\frac{860 \text{ tons}}{1\frac{1}{2}} = \text{say } 570 \text{ pairs only.}$$

Suppose a pair of bullocks with driver could be hired for 12 Rupees‡ a month, which is about as small a sum as could well keep the man and bullocks alive, then the total monthly cost of bullocks would be :—

570 pairs × 12 Rupees=6,840 Rs.

and the total yearly cost 6,840 Rs.×12 months = 82,080 Rs., which, capitalized at the present value of money, would be :—

82,080 Rs. ×20=16,41,600 Rupees.¶

* Vide Page 448 of Volume XI of the "Journal of the Society of Arts." According to the Sanitary Commissioners, "a considerably larger quantity of earth will be required in this country than in England," and "it will not be desirable to use, a second time, earth that has served to deodorize excreta." Vide page 27 of their Report on the Dry Earth System of Conservancy.

† This, from enquiries I have made, is, I learn, more than a pair of bullocks can do, but it is better to under-estimate the cost.

‡ Alwar Chetty receives from Government 17½ Rupees monthly for each cart he employs in the Fort, and Mr. Pritchard receives 25 Rupees monthly for each of his carts.

¶ Lest Government should think that this is an exaggeration, I beg to remind them that the Municipal Commissioners, in spite of all their efforts to reduce the expenditure, are now spending 80,000 Rupees yearly, or a Capital of 16 lacs of Rupees for scavenging alone, which proves the extraordinary cost of the removal of goods by carts and by manual labour.

Total cost of dry conservancy.

Without going further, I will sum up the total cost of universal dry conservancy for Madras as proposed to be carried out by Dr. Cornish.

	Rs.
Cost of Latrines.....	14,99,280
,, Urinals.....	2,58,000
,, Sheds.....	3,22,500
,, Land for latrines, urinals, and sheds.....	5,29,250
,, Establishment.....	32,50,800
,, Carting away manure.....	16,41,600
Total Rs...	75,01,430

I was as unprepared for this result, when I commenced the calculations, as, no doubt, Government will be to have it placed before them. Indeed, like many people, I supposed at first that there might be some grounds for Dr. Cornish's statement that Madras could be made a "model of cleanliness" for 2½ lacs of Rupees.* Yet no charge has been made for the carts which should be of a peculiar construction to prevent the escape of poisonous gases and which will cost a great deal of money —no charge for lighting the buildings during the night which is proposed by Dr. Cornish himself†—nor for the 25,800 earthenware pans required in the seats—nor for the iron receptacles for the urine and fæces—nor for the removal of the running stream of water proposed for use after defecation—no charge for the

* There is no limit to the requirements of dry conservancy. Every increase in the population will require more latrines, more urinals, more sheds, more clay and a larger establishment. If the population increases at the rate of 1½ per cent., there will be yearly $\frac{430,000 \times 1\frac{1}{2}}{100} = 6,450$ more people to be provided for, and they will require 10 latrines, 10 urinals, 10 sheds, and 40 scavengers. In the course of a few years the cost would be something frightful.

† Vide Page 19 of Doctor Cornish's Pamphlet.

clay*—no charge for supervision over the army of sweepers (3,870 in number)—and no charge for repairs of any kind whatsoever, which will be very heavy for works of this nature,—and yet the cost has reached the enormous capital of 75 lacs of Rupees. It may be urged that the clay will be brought and the manure carried away for nothing. Let me even grant the extravagant proposition, that there are men in Madras willing to risk a capital of $16\frac{1}{2}$ lacs† of Rupees on the mere chance of being able to sell manure. The balance will then be $75—16\frac{1}{2}=58\frac{1}{2}$ lacs of Rupees, and for this sum what is to be got—the removal of about one-twentieth or of one-hundreth of the sewage, according as 5 or 20 gallons of water are used per head of the population. The rate-payers of Madras who will ultimately have to defray the cost of *this* "improvement" would indeed do well to enquire whether Madras can be made "a model" of cleanliness for $2\frac{1}{2}$ lacs of Rupees; and if not, whether it would be worth while to secure the "improvement" for three quarters of a million sterling, in order that they might have all the sewage left behind.

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* If 1 ton suffices for 1,000 uses, and Madras contains 430,000 people, there will be required daily 430 tons of clay. The Engineer to the Municipal Commissioners informs me that his Department has to pay 8 Annas per cart load of clay. If each cart brings $\frac{1}{2}$ a ton (more than an ordinary load), the daily cost of the clay will be 430 Rupees, the monthly cost $430\times30=12{,}900$ Rupees, the yearly cost $12{,}900\times12=1{,}54{,}800$ Rupees, which represents a Capital of $1{,}54{,}800\times20=30{,}96{,}000$ Rupees, or nearly 31 lacs, which should properly be added to the estimate of 75 lacs.

† Dr. Cornish says, "In Madras, however, a European gentleman has, I believe, found it a paying concern to contract for the removal of the contents of barrack privies, to his grass land, in the outskirts of the town." If Mr. Pritchard, Veterinary Surgeon, is here referred to, the facts of the case are these. Mr. Pritchard employs 3 carts daily in taking the night soil of the European barrack in the Fort to his lands, but Government *pay him* 75 Rupees monthly to do so. Surely this is not the meaning which Doctor Cornish's statement conveys. It only proves that even urine and fæces, unmixed with water, will not be removed for nothing.

The Sanitary Commissioners on the cost of Dry Conservancy.

After the above was put in print, Colonel Orr, Secretary to Government in the Department of Public Works, kindly gave me a copy of the Sanitary Commissioners' Report on "The Dry Earth System of Conservancy." The opportunity has thus been afforded me of comparing my estimate with that prepared by those who have given the subject their more immediate attention, and who, therefore, are the most qualified persons to speak on it.

The Pamphlet, consisting as it does of a letter from the President of the Commission, and a report by Doctors Macfarlane and Montgomery on some experiments conducted under their immediate supervision by Dr. Blacklock at the General Hospital, contains the opinions of four Officers whose views should certainly carry great weight with them.

Dr. Blacklock says :—

"The expense of carrying out this plan in the Latrines of European and Native Hospitals in this country, is as follows. The calculation has been made with great care by Mr. Harvey, Assistant to the Professor of Chemistry.

Europeans—200.	Rs.	A.	P.
Pay for one Toty, at Rupees 7 per month.....	7	0	0
Do. six Toties do. 6 each per month...	36	0	0
For digging earth, to $1\frac{3}{4}$ men, at Rs. 8 per month per man.....	14	0	0
Two pairs of Bullocks with Cart and Driver, at 12 Annas per day per pair, for 30 days.....	39	4	0
To cover wear of spades, scoops, &c.....	3	12	0
Total...	100	0	0

or 8 Annas per man per month.

Natives—100.	Rs.	A.	P.
Pay for two Toties, at 6 Rupees per month, per man	12	0	0
For digging earth.....	2	0	0
Cart hire per month.....	5	12	0
To cover wear of spades, &c.....	0	4	0
Total...	20	0	0

or Annas 3 and Pies 3 nearly, per man per month."

The President of the Commission says :—

"As regards the cost of the system of dry earth sewage, according to Dr. Blacklock's experiment, it was found that the charge for each European patient was 8 Annas, and for each native 3 Annas and 3 Pies per mensem.

The cost, therefore, in Barracks, Jails, &c., when men using the Latrines are in health, would be about one-half of the above ; say, about 4 Annas per month per man, supposing the cost to be calculated on Dr. Blacklock's data."

I will now apply these data to the case of Madras which contains 430,000 people.

At 4 Annas per man per month, the monthly cost of dry conservancy will be :—

$$430{,}000 \times \tfrac{1}{4} \text{ Rupee} = 107{,}500 \text{ Rupees.}$$

The yearly cost will be :—

$$107{,}500 \text{ Rupees} \times 12 \text{ months} = 12{,}90{,}000 \text{ Rupees,}$$

which sum capitalized at the present value of money will be :—

$12{,}90{,}000 \times 20 = 258{,}00{,}000$ Rupees, *i. e.*, 258 lacs of Rupees, or upwards of $2\frac{1}{2}$ millions sterling.

And in this estimate the cost of the Latrines and of the land has been entirely omitted. Yet it is nearly $3\frac{1}{2}$ times the amount of my own estimate (75 lacs,) and approaches the cost of the stupendous Drainage Works of London.

It will now be seen why, in a previous part of this Report, I said that I was entirely in accord with the advocates of the system of dry conservancy—provided that the cost of it was not to be borne by the people.

Dry conservancy may be a capital thing, but Government only can afford to maintain it. To introduce it into Madras would indeed be to present the poor man with an elephant. The Municipal Commissioners would find it difficult to solve the problem, "how to maintain dry conservancy which will cost 13 lacs of Rupees yearly on their annual income of 3 lacs only."

It is really time to look facts in the face. The state of Madras is quite disgusting. Something must be done to remedy it sooner or later. Doctor Cornish says—"Adopt dry conservancy, and Madras will become a model of cleanliness for 2½ lacs of Rupees." The Sanitary Commissioners, on the other hand, report officially to Government that dry conservancy will cost 4 Annas per man per month, which, as I have shown, represents a capital of 258 lacs of Rupees, and is more than 100 times the amount of Dr. Cornish's estimate. What is the use of urging that the manure produced on the new principles will fetch money, or that the cost of collecting it will be, as declared by Dr. Cornish, "a mere trifle in the Municipal expenditure?" Can any people be found in Madras willing to buy manure of the value of 2½ millions sterling? Because, until they come forward, some one must pay for the experiment, and it is utterly impossible that the inhabitants can afford to do so.

When the advocates of dry conservancy themselves show that the cost of removing the excrementitious matters only will amount yearly to more than four times the whole Municipal income, it is really necessary to enquire whether there is not some other mode of cleansing Madras, and whether drainage by sewers is not, after all, both the cheapest and the most effectual means of doing it.

CHAPTER IV.

OBJECTIONS TO SEWERS ANSWERED.

Before passing on to a description of the project now submitted to Government, it is necessary that the general objections to the system of drainage by sewers should be met. Fortunately, these objections have been very fully stated by the same Officer who has pleaded so strongly on behalf of universal dry conservancy. When the arguments on both sides of the question shall have been fully stated, it will not be difficult for Government to decide between them.

The importance of the general principles of drainage.

At the present time, when sanitary questions are attracting great attention, it is of vital importance that the general principles of water-supply, drainage, barrack construction, &c., should be thoroughly discussed. If mistakes are made at the outset in carrying out large and important works, the chances are that they will be repeated over and over again, and at an enormous cost to Government. Whereas, if the correct principles of any one subject are clearly defined, there is every hope of their universal adoption. As this is the first project which has been submitted to the Madras Government for the complete drainage of a large town in the Presidency, it would be a grievous error to carry it out if it should be based on erroneous theories. On this account, therefore, I have considered that I should be discharging my duty to Government better by omitting nothing in this Report bearing on the question of drainage than by confining myself strictly to the immediate subject matter.

Physical conditions of England and India compared.

The reason why dry conservancy has "taken" better with the Indian than with the English public is, that the physical conditions of this country are so much more favourable to its development. England has a damp, while India has a dry climate. The heat of the sun, which is so important an agent in the dry system, acts perfectly in India. Moisture is rapidly absorbed, and clay easily dried. In England, the damp air and the continued absence of sunshine for many days together are obstacles, though not insurmountable ones, to the perfect working of the system. In England, moreover, it is raining more or less constantly throughout the year, while in India the entire supply of rain is obtained in a few days. The rivers in England are flowing all the year round. Those in the south of India are dry for some months. All these facts are urged as arguments against sewers.

Doctor Cornish says—

"Let anybody who seriously considers the question, just think,—first, where the water to flush sewers is to come from, and, secondly, where the sewage is to go to, after it leaves the crowded community. Let him reflect upon the fact that the great tract of country sloping away from the mountain ridge—the 'back bone' of India—to the Coromandel Coast, and whose rivers flow eastward, is naturally so arid, that for months together the streams which take their rise in the Western Ghauts, and empty their storm-waters into the Bay of Bengal, are nothing more than wilds of sandy waste, with perhaps a tiny stream meandering through the middle."*

The argument put in few words is this—"Because the rivers in Southern India do not flow all the year round, therefore there must always be an insufficiency of water." The fallacy is so obvious that I have only to state the proposition in other terms, and it will be admitted. "Because wheat does not grow all the year round in England, therefore there must always be an

* Vide Page 7 of Doctor Cornish's Pamphlet.

insufficiency of wheat there." But, surely, if people will grow a sufficient quantity of wheat in the season, there need be no lack at any time of the year. And so, if sufficient water is stored in the monsoon and when the rivers *are* flowing, there need be no lack during the hot months. To prove that we have not sufficient water, it is necessary to show that the rainfall, the source of all water in every country,* is deficient. Yet what is the case? The rainfall in India on the average is double that of England. It is true that the evaporation is greater, but after making every allowance for loss due to this cause, there is an enormous balance of water available for the use of man. Has India, then, any reason to complain? Every effort which has been made to store water in the country is a standing protest against the statement that we have not sufficient water. The success of even small tanks is very great. Would Government otherwise keep them in repair? What works can be better adapted to the purpose of store-reservoirs than large tanks and annicuts? It is a great mistake to suppose that all the towns in England draw their water-supply from large and ever-flowing rivers, and that these large rivers are necessary to works of drainage. Numerous towns in England are supplied with water from store-reservoirs exactly similar to the tanks of India, and their success is complete. Doctor Cornish says that water in India "requires to be raised from *below* the surface," as if it had been proposed to supply large towns from wells. All water comes originally from above, and if the same plan is adopted in this country to secure a sufficiency of water as is adopted in England, *i. e.*, to dam up streams and form large basins, why need we go *below* the surface for our supply?

There is a sufficiency of water in India for all purposes.

The following is a list of most of the principal towns in the Madras Presidency. Through the help of several Officers, each personally acquainted with some of the localities mentioned, I

* I am, of course, speaking generally.

have been able to indicate the sources of supply for most of the towns.

Name of Town.	Sources of Supply.	Remarks.
Ganjam	A river flows by the town.	I have not been able to obtain much information about these towns, for the localities have not been examined for purposes of water-supply.
Russelcondah	....	
Berhampore	.....	
Chicacole...	A large river flows by the town.	
Waltair.....	A large supply can be secured from some neighbouring hills.	It is supposed that an unlimited supply might be brought from hills distant about 4 or 5 miles. Vide page 377, Vol. II., Report of the Commissioners "On the Sanitary State of the Army in India." This is confirmed by information obtained from an Officer of Engineers personally acquainted with the locality.
Samulcotta	A channel from the Godavery annicut flows to the town.	
Coringa	Do. do. do.	
Coconada...	Do. do. do.	
Dowlaishweram	Stands near the Godavery annicut.	
Ellore...	A channel from the Kistnah annicut flows to the town.	
Masulipatam...	Do. do do.	This town is to be supplied with water now that the necessity is very urgent.
Bezwarah..... ...	Stands near the Kistnah annicut.	
Guntoor	.....	The locality has not been examined for purposes of water-supply.
Ongole.	.....	I can obtain no information about this town.
Cumbum.....	One of the largest Tanks in the country is close to the town.	This tank is like a lake, and is seldom, if ever, dry.
Nellore.....	River Pennar, the annicut across which is near the town.	
Cuddapah	The River Pennar flows close to the town, and it is intended to bring an irrigation channel from Kurnool to it.	There is no doubt that Cuddapah can be well supplied with water if Government wish it.

Name of Town.	Sources of Supply.	Remarks.
Kurnool	A channel from the annicut across the Toongabudra runs near the town.	
Nundial	The main channel from the Kurnool annicut will run within 3 miles of Nundial, and when it is required a branch channel can be taken to the town.	I am informed on the best possible authority that the water of the Toongabudra will be taken to Nundial in about 12 months from this date.
Bellary.....	A project for supplying this town with water has already been before Government.	This is perhaps the driest district in the Presidency, yet I learn that abundance of water can be obtained for Bellary. Time only is required to mature a project, so that it may be put before Government in such a shape as to admit of their forming a judgment on the subject.
Madras.....	Red Hill Tank and Rivers Cortelliar and Cooum.	W. Fraser, Esq., C. E., informs me that from the Cortelliar only he can obtain at least 20 gallons per head of the population.
St. Thomas' Mount.	River Adyar.....	I believe quite sufficient water could be obtained by putting a dam across the river.
Vellore..... } Arcot... ... . }	Both stand near the annicut across the Palar.	
Salem...	The River Tirugamu Muttai flows to the town from the Shervaroy and Surragoomallay Hills, and has water even in the dry weather. Moreover, a large quantity could be stored near the Hills.	I am informed by two Officers personally acquainted with the locality, that this town can be easily and abundantly supplied with water.
Coimbatore...	Even at present there are 2 or 3 large tanks near the station which have water in them for the greater part of the year, although it is used for irrigating an extensive tract of rice ground.	"This station could be fully supplied, and that at a level commanding the native town, if the surplus water of the Noyel River were stored near the head of the Bolumpatty Valley." Extract from a letter to me from an Officer personally acquainted with the locality.

Name of Town.	Sources of Supply.	Remarks.
Tranquebar.....	These towns are at present supplied from the Cauvery, but it runs dry in the hot season.	All the towns on the delta of, or near the Cauvery, could be supplied with water all the year round, if large reservoirs were formed (as has already been proposed) on the tributaries of this river.
Combaconum ...		
Trichinopoly		
Tanjore	These towns are also dependent on the Cauvery, but at both there are local streams, the floods of which might be stored.	
Negapatam... ...		
Madura...		I cannot obtain exact information about these towns.
Palamcotta... ...	It stands near a river.	

To the worst that may be said of any town in this list, it may be replied that the locality has not been examined specially for purposes of water-supply. All the towns on the Malabar side of India are omitted, as hardly any one would maintain that there was an insufficiency of water on the Western Coast. I believe that the following extract from a letter to me by W. Fraser, Esq., C. E., expresses briefly the general opinion of all Engineers in this country :—

"I have had occasion to consider this subject a good deal, and I am of opinion that abundance of water can be had everywhere in the South of India if proper means be adopted to secure it, and that it is difficult to conceive a case where money spent in this way would not be a profitable investment."

So far, therefore, as drainage depends on water-supply, is there any reasonable cause to object to sewers ?*

Water for flushing sewers.

As to the quantity of water required for flushing sewers which Doctor Cornish supposes must be very great, the follow-

* The more I enquire of my brother-Officers as to the possibility of storing water for irrigation and other purposes up-country, the stronger assurance I obtain of the facilities for doing so.

ing extract from a Report on the Drainage of Bombay, by Robert Rawlinson Esq., C. E., "who," according to Sir Charles Wood, "has earned a high reputation for skill in that branch of Engineering,"* will show that very little water suffices for the purpose :—

"During the dry season in Bombay the sewers should be regularly flushed with fresh water. The volume of water used need not be large, nor the expense very great"..... ..... "At the great hospitals on the Bosphorus used by the British Army during the Crimean war, large wine casks were used as flushing tanks. These were placed over the heads of the sewers, and were regularly filled from the Bosphorus by labourers (natives) who carried the water to fill the casks, then an orderly suddenly opened a valve, some 6 inches square, which discharged the water, about 250 gallons, in a few seconds. These sewers were large and rudely constructed, with flat bottoms, some 3 feet wide, but they were flushed free from deposit by the means described."†

What could be better for sewers in this country than the ordinary water-carts used in Madras filled by the aid of pecottahs? The large sewer in Bangalore is flushed throughout the year with water supplied from an ordinary tank.

Flushing arrangements for the Madras sewers.

The sewers proposed in this Project will be as perfectly smooth as skill can make them, and not one of them will be so wide at the bottom as the above-mentioned, while most of them will have a diameter at bottom of only one foot. So far as Madras is concerned there need be no anxiety about a deficiency of water for flushing purposes. I could only wish that there was not so much available under the surface as there is, because the cost of building the sewers is proportionately increased. The flushing arrangements will be most complete and will cost nothing after the sewers are once built.

The next objection to sewers is condensed in the question,

* Vide Page 97 of "Correspondence on the subject of the Drainage of Bombay."
† Vide Page 101.—*Ibid.*

"Where is the sewage to go to?" And the reply suggested is, "The rivers."

"The great rivers, the Godavery, the Kistna, and the Cauvery, which contain more or less water throughout the year, do not run near to many populous towns, and are practically unavailable for the purpose. Along the Coast, sewage might probably be pumped into the sea, but the difficulty would still remain with inland towns, such as Bangalore and Secunderabad."*

Rivers, as outfalls, no part of the sewer system

The error in this reasoning lies in supposing that rivers, as outfalls for sewage, are a *necessary* part of the sewer system. They form no part of it at all. It is indeed unfortunate that in so many instances in England sewers should have been led to rivers, but this is not the fault of the sewers but of the people who built them. According to the same mode of reasoning railways may be objected to, because they have often (as in the case of the first portion of the Madras Line) been carried not to the towns where one would suppose they would be required, but away from the towns into the wastes of the country.

All sewage should be utilized on land.

All sewage, and especially in this country, should be returned to the soil—to the same place where the solid manure of dry conservancy is to be conveyed. Those who are so anxious to preserve urine and fæces as manure should not forget that, after all, they cannot manage in India without water, which must descend as rain or be raised artificially before crops can be made to grow. The only difference, so far as the agricultural part of the question is concerned, between solid manure and liquid sewage, is that in the first case you have an article which is almost useless by itself, and in the second you have nearly all that is required to produce anything. The mistake lies in reasoning from England to India without considering the different conditions of atmosphere, soil, &c., prevailing in the two countries. In England it is raining more or less throughout the year, and the first question which the agriculturist puts to

* Vide Page 7 of Dr. Cornish's Pamphlet.

himself is, "How shall I get rid of the water?" In India it rains for about 20 or 30 days, and the first question the ryot asks is, "From where shall I get water?" The soil in England in its normal state is saturated with moisture, and every effort is made to keep it dry. The soil in India is dry, and every effort is made to keep it moist. Sewage is manure in a diluted state. But its use even in England, *now that they understand how the sewage should be applied and what crops should be grown under it*, is almost uniformly successful and is advocated by the greatest authorities. Doctor Cornish, however, maintains a different position.

"Practically, the liquid sewage system in Europe has failed as regards its use to the agriculturist, for the simple reason that the more valuable portions of the sewage have been decomposed and dissipated in the form of highly poisonous and offensive gases, leaving only the more stable and worthless constituents remaining in the mixed fluid of the drains. The farmers who expected in the sewage laid on to their grounds perpetual streams of fluid guano, have been chagrined to find that the ammonia has flown away, and the phosphoric compounds have dissolved into thin air, leaving nothing but a fetid fluid behind no more fertilizing in its properties than ordinary river water."*

But, in admitting this, Doctor Cornish grants almost all that we contend for. Surely river water in India applied to land will produce enormous profits. Moreover, he does not adduce any proof of his statement that the application of liquid sewage has practically failed. I will, however, show that even in England the evidence now all inclines the other way.

Instances of the utilization of sewage.

The case of Edinburgh, where, by the use of sewage, land has risen in yearly rent value from £2 to £6 per acre to from £30 to £40 per acre (Scotch) is so well known that I need not dwell on it. About Milan land yields a net rent of £8 per acre. The meadows are mown four times in the year for stable feeding, and besides this three crops of hay are yearly obtained by sewage-irrigation. At Clitheroe in Lancashire it has been

* Vide Page 14 of Dr. Cornish's Pamphlet.

proved that the fertilizing properties of sewage water are nearly four times as great as those of common farmyard manure. At Mansfield, in Nottinghamshire, land has risen in rent value from 4*s*. 6*d*. to £14 per acre. At Ashburton and at other towns in Devonshire, liquid sewage has been applied for 50 years, and the yearly rent of land has reached £8 to £12 per acre, while land not improved with sewage yields a yearly rent of only £1½ to £2 per acre.* But all these, though well known, are old instances of the effect of the application of liquid sewage. The most recent instance, and the one which is attracting so much attention in England, and which, it is supposed, will at last decide the question in favour of the use of liquid sewage, is that of Croydon.† The inhabitants have

* For all these facts vide "Dempsey's Rudimentary Treatise on the Drainage of Towns and Buildings," Weale's Series.

† THE SEWAGE EXPERIMENT AT CROYDON.—"We saw the other day several fields covered with 12 to 14 tons of grass per acre," says a writer in the *Agricultural Gazette*. "It stood as high as a walking stick, and as thick upon the ground as it could grow. Of a dark green colour, and still succulent from end to end of every stalk, with the flower spike barely through, it was then the very best green food that could be given to milch cows. And for this purpose it was being sold. Cow keepers in the neighbourhood were coming all day long and carrying it away, paying 1*s*. a rod, or at the rate of £8 per acre for it on the spot. And many tons (from 6 to 30) were being sent to London cow-houses: 25*s*. a ton being charged for it delivered there. The produce had been after the rate of 13 and 14 tons per acre. A second cut will be ready there before the middle of this month, a third towards the end of July, and a fourth in September. Perhaps a fifth may be obtained, or the last growth may be grazed upon the land. The particular field to which we are alluding now was sown in 1862. It yielded 4, and some of it 5 crops last year—12, 10, 7 and 5 tons per acre, respectively; and it looks as well this year as ever it has done. The land is worth barely 30*s*. per acre naturally. There are some 240 acres thus in grass, for the most part in Italian rye-grass. The enormous productiveness of that plant under favoring circumstances has probably hardly anywhere as yet been fully realized. The land in question, about 300 acres in extent, is let to the Croydon Board of Health, and they have sublet it to their tenant Mr. Marriage, for a term of 9 years, at £5 per acre. It lies about two miles and a half from Croydon. Mr. Marriage receives the whole of the sewage of Croydon for the use of this land; and passing the whole (about one million or more gallons per day) over the surface of the land, he thus removes from it its noxious and fertilizing elements, and converts the filthy turbid ditch-water which comes on to the farm into the

been *compelled* to make use of the sewage of their town for the irrigation of land. The result is, that enormous crops of green food have been obtained, and this without any nuisance or inconvenience, while at the same time the surplus water after irrigation is found, on entering the River Wandle, to be purer than the water of the river itself. At Beddington, near Croydon, mangel-wurzel has been grown most successfully by the aid of sewage. Sewage is also utilized as manure in Wolverhampton, Carlisle, Clipstone, Horde, and many other towns. At Manchester, the local authorities find that half the cost of removing the town sewage is repaid them by its market value, and they believe that the system can be organized so as to defray its own charges and leave a surplus too. Even in London, contractors have lately come forward and offered to remove the whole of the London sewage without any expense to the inhabitants, on condition that they should be allowed to have the use of it for a term of 50 years. They propose to utilize it on 60,000 acres of land in Essex. But the Corporation of London are not, it appears, willing to let them have it on these terms, because it is contended by parties interested in the matter that the sewage can be sold at a high rate, and that thus

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clear and limpid stream which leaves it. At the farm, it is made to flow in furrows about 16½ yards apart, from which it is gradually poured out over the intervening lands.

Although legal proceedings were taken some years ago against the Board of Health because of the nuisance they were guilty of when only a small piece of land had been used, none has yet been proved or even charged against Mr. Marriage and his farm. One million or more gallons have to be used and purified every day, so that at short intervals every field is continually throughout the year being flooded.

The large produce, probably 8,000 tons or more of green food, annually disappears as fast as it is grown; and there will, no doubt, prove to be room enough in the demand of 3,000,000 of people for all the produce which will one day similarly arise out of a proper use of the 20,000,000 cubic feet per diem of sewage water which is about the quantity in the way of the Metropolitan Board of Works."—*The Builder*, volume XXII., No. 1,115, page 451, June 18th, 1864.

it will ultimately defray the cost of the Metropolitan drainage works.*

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* "A very great question has just been put in the way of practical solution. After an enquiry, facilitated by the best professional evidence, a select Committee of the House of Commons has arrived at the conclusion that it is not only practicable, but would be found actually profitable, to turn the sewage of towns to account in fertilizing the land for the purposes of ordinary agriculture. Though the subject is by no means a new one, yet the question has recently increased so greatly in importance, and embraces at the present moment so many problems of urgency, that we must bespeak for it the especial attention of our readers.

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The successful solution of the problem on which the Committee has now reported, will answer all these questions together. If we can take the sewage of our towns from our rivers, and transfer it to the land, we shall at once escape a great evil and gain a great good. Land, and land only, will take up this refuse and absorb it with entire impunity. We can do no harm to our soil or its products. The roots of growing plants possess a power more subtle than the chemist's, of disintegrating this matter and appropriating its most noxious ingredients to their own benefit. The most delicate vegetables can be raised in absolute purity from a bed of manure. Treat sewage as guano, and it becomes, instead of an unmanageable nuisance, a substance of infinite value. It will not combine safely either with air or with water, but it has a natural affinity to earth. After trying two elements with it, let us try a third. In the new experiment we can certainly do no harm; we shall probably do a great deal of good.

In fact, there has never been a doubt in the matter except as concerned the practical way of going to work. The difficulties in view were all mechanical. Town sewage would be of great use in the country—that was admitted, but how to get it there? Could the transfer be so managed as to pay the cost? It is very easy to run a drain into a stream close by, but could a drain be run into the country, with an outfall convenient for the wants of the agriculturist? As these were the questions on which the problem turned, so they are the questions, we rejoice to find, which are now answered favorably in the Committee's Report. Engineers of the greatest experience and reputation combined in explaining the machinery required for the purposes in view, and the charge likely to be entailed. Not only was there nothing impracticable in the process, but nothing forbidding in the expense. The work could actually be done at the present time with a profit rather than a loss on doing it, and as the demand for the manure became greater, and the system was improved, the profit would be materially enhanced. Already, it is said, the local authorities at Manchester find that half what they spend in removing the town sewage is re-paid them by its market value, and the system, we are told, could be so organized as to defray its own charges, and leave a surplus too. The Committee, indeed, are of opinion, that the great Metropolitan drainage scheme must be regarded as defective, in so far as it omits the utilization of the sewage, but

The application of sewage to land is, like other branches of agriculture, a science of itself. Occasional failures will occur, and many more must be expected until the subject is better understood, but these are or will be due to want of knowledge

The universal application of sewage to land advocated in England.

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that imperfection can probably be remedied without much difficulty when once the new demand has been established, and the system of supply arranged. It is very properly intimated in the Report that the first object should be the discontinuance of mischief. It will certainly be a very welcome incident if it is found that the rate-payers of a town would experience a pecuniary benefit in addition to a sanitary gain."

—*Extract from an article in the London 'Times' of the 7th September*, 1864.

"Those who remember the rival debates and proceedings of the Common Council and the Metropolitan Board of Works, a few days ago, will not be at all surprised to learn that a deputation from the former body has just had an interview with the Prime Minister on the subject of the sewage of the Metropolis. * * * * *

Up to a very recent time it was not believed that the sewage of a town could really be made to produce any considerable revenue. The fact had often been asserted, and the theory itself could be plausibly maintained, but there was no evidence or conviction that the system could be practically worked. Lately, however, and especially since the enquiries made by Parliamentary Committees, a different opinion has grown in favor, and the belief, we may say, is now generally entertained that a good system of town drainage may be made to pay its own expenses, and leave a surplus revenue for the benefit of the community. * * * *

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Messrs. Hope and Napier proposed to commence operations near the great drainage reservoirs down the river, to take the sewage from those points straight away to the Essex coast, and then apply it to the reclamation and fertilization of some 20,000 acres of sea-sand flats to be embanked for the purpose. * *

Mr. Ellis proposed to carry the sewage back again from the reservoirs to the Hampstead and Highgate hills, and from those elevations to distribute it over large tracts of country for the ordinary purposes of agriculture. * * *

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Messrs. Hope and Napier asked for a concession of the Metropolitan sewage for 50 years, on the condition that after deducting from the profits of the enterprise a sum equal to 10 per cent. on the outlay or capital of 2,000,000, the residue should be equally divided between the Company and the Board. * *

But, in the meanwhile, and since this scheme had been entertained, a belief had arisen in the extraordinary value of sewage as an agricultural manure; insomuch that when the Common Council met, an estimate was actually put in giving £2,899,972 as the annual value of that commodity which Mr. Thwaites and his colleagues were preparing to mortgage for 50 years at a nominal rate of profit."

—*Extracts from an article in the London 'Times' of the 25th November* 1864.

and judgment on the part of those who use the sewage and not to the thing itself. Every year the use of liquid sewage in England increases, and the *belief in its value is now general.* It is not a perfect manure, but no substance can possibly be a perfect manure. All that should be contended for sewage is, that it has great fertilizing properties.

"The Evidence" of the Parliamentary Committee of Enquiry in their second Report "asserts that sewage contains the elements of every crop which is grown: and that, as compared with solid manure, there are advantages in the application of sewage to the land. In the application of solid manure, loss is sustained by evaporation: but no such loss occurs with sewage. In the application of solid manure to the land, years may pass before its entire productive qualities are all absorbed, causing a loss to the farmer by the slow return of the capital invested in manure; but in the application of sewage, or any liquid manure, no such loss occurs, as every particle of it comes into immediate action on the crop in a day or two."*

The Social Science Association in England, at their last Congress held in York, in September 1864, under the Presidentship of Lord Brougham, resolved:—

"That this Meeting regards the sewage of towns as of undoubted value as a fertilizer of the soil; and while recognizing the importance of getting rid of it as a source of disease from houses, is decidedly of opinion that the true destination of sewage is the soil; and, therefore, strongly recommends the continuance of all efforts to divert it from rivers, and to distribute it over the land of the country."†

But the last Committee which has been appointed by the House of Commons to enquire into the subject of the utilization of sewage, and which sat during the months of May, June, and July of *last year* (1864), urge, in their Report, that a *law should be passed compelling towns to use their sewage on land.*

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* Vide Page 43 of Vol. XXI. of "The Builder," for January 17, 1863.

† Vide Page 717, Vol. XXII. of "The Builder," for October 1, 1864.

"Your Committee have come to the conclusion that, it is not only possible to utilize the sewage of towns, by conveying it in a liquid state, through mains and pipes to the country, but that such an undertaking may be made to result in pecuniary benefit to the rate-payers of the towns where sewage is thus utilized."

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"We recommend that the important object of completely freeing the entire basins of rivers from pollution should be rendered possible by general legislative enactment, enabling the inhabitants of such entire districts to adopt some controlling power for that purpose: but it should include a provision for compelling Local Boards to render the sewage of their districts innocuous by application to the land for agricultural purposes."*

Can better testimony to the advantage of using sewage be brought forward?

Baron Liebig says—

"The employment of sewage in agriculture would make it possible to bring large tracts of land into cultivation, which hitherto, owing to the expense of tillage, had been laid waste and neglected:

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"It is neither fantastic nor ridiculous to believe that, without purchasing foreign manure, and by a judicious utilization of the sewage of towns and villages, England would be able to dispense with the importation of food from abroad."†

And again, in his very last letter on this subject addressed to Lord Robert Montague, he says—

"If clearly understood and properly managed, the employment of sewage will prove a blessing to agriculture."‡

I refrain from bringing forward more evidence on this point for fear of wearying Government.

If all this can be declared of England, where already there

* Vide Page 690, Vol. XXII, of "The Builder," for September 17, 1864.

† Vide Page 657, Vol. XI, of "Journal of the Society of Arts," for August 21, 1863.

‡ Vide Page 776, Vol. XII, of "Journal of the Society of Arts," for October 28, 1864.

is too much moisture in the soil, what wonderful fertility might be produced with sewage in India ? Pour water on the land—flood it if you like—and what is the result ? A succession of crops. Would not better crops be secured with water mixed with manure ? It may be granted that solid manure, bulk for bulk, is more valuable than sewage. But that is not the point at issue. The point is, whether solid manure in a dry country like India with 20 or 30 wet days in the year (Doctor Cornish says 12 days only, which is all the better for my argument) is worth 20 or 100 times its bulk of sewage, which, according as 5 or 20 gallons of water are used per head of the population I have already shown, it will amount to. And even this is not putting the case fairly, because every pound of solid manure will have to be carried to the fields, and then spread and mixed with the soil by manual labour, whereas liquid sewage can be applied to the land by simply opening a sluice. Thus drainage works in India should be looked upon as works of artificial irrigation—that they will ultimately become so, I have no doubt whatever.* The land will make its claim good to every drop of water and every ounce of manure, in spite of all that may be done to prevent it. It will, in the proper place, be shown in how remarkably favourable a position Madras is situated for the utilization of its sewage.

Outfall for the sewage of inland towns.

It is necessary that I should here answer the question "Where is the sewage of all inland towns to flow to ?"† It would really seem, from the manner in which this is put, as if India were the only country in the world which had inland towns. Where does all the sewage of all the inland towns of Europe go to ? They do not all stand on, or even near, rivers. India is no worse situated for the disposal of the sewage of her inland towns than England is. And if the sewage is in India always returned to the soil, as the Parliamentary Committee

* Already the sewage of Bangalore fetches money; it is true, a very small sum, but time must be given to enable the people to learn the full value of liquid manure.

† Vide Page 7 of Doctor Cornish's Pamphlet.

propose it shall be in England, what does this objection, with reference to inland towns, amount to?

The next objection will be understood from the following extract:

Water-closets not necessarily a part of the sewer system.

"The greatest advantage of all would be the doing away with the necessity for costly drainage works, which it is thought will never be of any use in keeping the town clean of ordure, for the simple reason that natives *will not sit upon, or use water-closets.*"*

This is indeed putting the cart before the horse. To do away with drainage works *because* men will not sit in a particular way at a particular time! Are we then to suppose that sewers were introduced to suit water-closets? Until now it has always been believed that water-closets were introduced to suit sewers. But why will not natives use water-closets? and how has this been ascertained in Madras? Perhaps they object to sit on them in the same manner as Europeans. Nothing would be easier than to design water-closets to admit of natives sitting with their feet on the seats. It is suggested, however, that it will take "100 years for them to get over their prejudices."† This is a long time to give such an intelligent people of whom and their prejudices even Doctor Cornish says—

"Many of these" *i. e.*, prejudices "must be looked upon as simply the result of ignorance or of habit and custom. Natives are not above learning and following good examples, when they see with their own eyes the superiority of many of our modern appliances of civilization over their own rude and clumsy contrivances."‡

Supposing that hereafter it should become advisable to introduce water-closets, is not this sufficient to prove that they will be used?‖

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* Vide Page 19 of Doctor Cornish's Pamphlet.

† Vide Page 19.—*Ibid.*

‡ Vide Page 9.—*Ibid.*

‖ At one time it was urged in Bombay that natives would not use water supplied on the English system—*i. e.*, through iron pipes. But this is not found to be the case. If water-supply and drainage works are to be delayed on account of some *supposed* prejudices on the part of the natives against them, it will be long before any improvements are made in our towns.

Dry conservancy, as proposed at present, suited to a low state of society only.

Whatever may be said to the contrary, that system of conservancy is the best which, provided it is not injurious to health, can dispense with the employment of men and women on duties which no human being should be called upon to perform. Water-closets require no toties, and 40 men could easily look after all the sewers of Madras. But dry conservancy in Madras would require that 4,000 of the inhabitants should be engaged in one of the most disgusting of occupations. The use of water-closets, however, is altogether beside the question of drainage. Whether the excrement is removed by means of them or is carried away in carts, the sewers will still have quite sufficient work to do. I have mentioned the subject of water-closets in order that it may not be supposed I wish to pass over anything which may even be *thought* an objection to sewers.

Materials to be used in the construction of sewers.

The next argument against sewers will be seen from the following extract :—

"India, for many months of the year, is a dry and thirsty land, so greedy of moisture, that unless sewers be built of some less absorbent material than brick and mortar, the soil will take up all the watery parts of the sewage, leaving the solids to choke up the artificial channels. This state of things obtains in the town of Madras throughout the hot and dry seasons, and it is no wonder that, under such circumstances, the odour of our drains should have obtained a proverbially evil repute.

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Of Madras it has been averred by competent authority, that before the construction of drains, its abominations were not so noticeable as they have since become. The attempts hitherto made to follow in Indian towns the European model of sewerage, have undoubtedly had the effect of making those towns more pestiferous than they were before sewers were thought of."*

No attempts, that can really be called such, have yet been made to follow the European model of sewerage. It is notorious that in Madras the worst kind of bricks and ordinary (not even hydraulic) mortar have been used. The mortar, moreover,

* Vide Page 8 of Doctor Cornish's Pamphlet.

is made of *shell* lime. It is not extraordinary, therefore, that the drains should be a nuisance. But to argue that because bad materials are used in Madras all sewers are objectionable, is tantamount to saying that because bad flour is sometimes used all bread is unwholesome. If proper bricks and proper hydraulic mortar are used, sewers could not be objected to. In the project now submitted, I have provided that steam-pressed bricks only shall be used, and that they shall be set in hydraulic cement, and that the sewers shall be lined *throughout* with a coating of asphalte. The subject of materials is so entirely a professional one, that I will not pursue it further in this place.

The European system of sewerage has had no trial in India.

There is really no similarity at all between the European model of sewerage and the system which has been carried out in Madras. It is absurd to compare the two. In Madras the street drains are all open—in England they are always closed. In Madras the drains are near the surface—in England they are at a considerable depth underground. In Madras no attention whatever is paid to the slopes of the drains—whereas in England the inclinations are regulated on scientific principles, and the drains are laid with almost mathematical precision.

Now, when it is remembered that the whole question of drainage is one of slope—that it is necessary that every single drain and pipe should be laid with the utmost care and at such an inclination as shall enable it to keep itself free from deposit—and when nothing of this kind is attempted in Madras, where the drains are built solely with reference to the slope of the surface of the ground, and not at all with regard to the inclination which each drain should have—is it surprising that the present drainage system should be a failure and a nuisance? It would, on the contrary, be extraordinary if it were otherwise. The Madras sewerage has failed simply because it is totally *unlike* the model system adopted in England. So far, therefore, from being discouraged by the present state of the

Madras drains, we should rather be encouraged by it to give the European system what it has not yet had,—a trial.

Noxious odours not peculiar to sewers, but incidental to all systems of conservancy.

The next objection to sewers is, that they create a great nuisance, and this, if it were true of a proper system of sewers only, and not of other systems of conservancy, would certainly be a more valid one than any yet brought forward. But, unfortunately, this nuisance is an objection to all systems of conservancy. Where foul matter is disposed of, there must be more or less smell. Latrines on the dry conservancy principle are not inodorous but merely less offensive than those in which water is used.* And dry conservancy after all, contemplates merely the removal of excrementitious matters, and leaves the question of the nuisance caused by refuse water untouched. So what is to be done ? Sewers remove *all* liquid refuse with a little nuisance. Dry conservancy, so far as it goes, removes some of the refuse with, say, less nuisance,—but unfortunately it does not go very far, for it leaves at least nineteen-twentieths of the refuse behind. We are merely on the horns of a dilemma, and must choose between two evils. Of these, sewers are incomparably the less evil, because, at least, they do form a *complete* system, and the effect of them is known, but dry conservancy is merely a partial *expedient*, and the fearful consequences of leaving waste water stagnating about our dwellings cannot be foreseen. To combine the two systems, *i. e.*, to utilize excrementitious matters in public privies on dry conservancy principles and to have a system of sewers, would be impossible. The expense of such an arrangement would ruin even Bombay itself.

Sewers can be rendered innocuous by disinfection.

Those who exaggerate the nuisance caused by sewers should remember that in a very short time this will be no argument at all. The subject of deodorizing and disinfecting sewage is in a most hopeful state. Already it has been announced that the Thames can be disinfected for £20,000 a year. That is not a

* If there is any doubt of this, a visit to the model latrine on the north bank of the Cooum near Poodoopett will convince the most sceptical.

large sum for so great a sewer. Mr. Norton's experiments in Madras, moreover, have not been so unsuccessful that it can be said sewers will never be disinfected cheaply ; that they can be disinfected, there is no doubt. The question now has resolved itself into one of expense only. Some of the greatest analytical Chemists* of the day have declared that it is quite possible both to prevent any smell arising from sewers, and to retain at the same time the manuring properties of the sewage. Indeed, in

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* *Examination of Doctor Letheby before the Royal Commission on the Sanitary State of the Army in India :—*

" Q. Has your attention at all been directed to any other disinfectants ?

A. It has been directed to nearly all the disinfectants.

Q. Do you think them of any use ?

A. I do not think they are, for water.

Q. I mean for the sewers ?

A. If your object is not to disinfect but to keep the sewage from putrefying, so that no bad odours may be evolved from it, in the course of its discharge there are several things which will stop its putrefaction, and give you an opportunity of transporting the material without any danger, but I do not know of any substance that can be used in reasonable quantities which has the power completely of arresting putrefaction.

Q. What do you recommend as the most useful ?

A. Carbolic acid of coal tar.

Q. What is that commonly called in commerce ?

A. It is commonly called creosote. The creosote of commerce is taken from wood tar, but this is the creosote of coal tar ; creosote is the common name of it, and it is a powerful antiseptic ; it is the chief constitutent of the dead oil or tar used for preserving timber.

Q. Is it easily made ?

A. It is easily made from gas tar.

Q. And is it inexpensive ?

A. Very inexpensive.

Q. Applied to sewers or cesspools, does it prevent putrefaction ?

A. It does.

Q. And destroys the putrid matter ?

A. No, it stops putrefaction ; it does not destroy the organic matter.

Q. That is what is commonly meant by an antiseptic ?

A. Yes.

Q. Is that the article known in commerce as McDougall's powder or fluid.

A. It is.

Q. Is that used for stopping decomposition ?

A. Yes.

England, antiseptics *are already used* with the best effects. For Madras, I have arranged that the sewers shall be throughout

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Q. Would you recommend it for that purpose ?

A. Yes, I would, for we have tried it very largely in some of the sewers of the city, and with a good effect.

Q. Is it preferable to Condy's solution ?

A. Condy's solution is more powerful as a deodorizer ; it is a true disinfectant, and oxydizes the putrid matter, whereas McDougall's liquid simply prevents putrefaction."—*Vide Page* 269, *Vol. I. of the "Report of the Commissioners."*

Examination of Doctor Angus Smith, F. R. S., before the Royal Commission on the Sanitary State of the Army in India.

" Q. You are prepared to give evidence upon the subject of disinfectants ?

A. Yes, I came for that purpose. * * * In speaking of disinfectants, I am disposed to say that there is not very much information upon the subject, for the subject has not until very lately been taken up with any enlarged views, but only for trifling purposes, and in very narrow ranges. I would divide the class of bodies used for disinfectors into two kinds—first, disinfectants ; and next, antiseptics. There are many bodies which destroy the putrefactive condition of the organic matter, but which do not prevent putrefaction from continuing—they destroy it only for a moment, or, in other words, they destroy the products formed, and leave the substance to form more. Antiseptics may or may not destroy the products, but they prevent their recurrence. I think, therefore, that whenever we use disinfectants it is important that we should use antiseptic bodies that will prevent decomposition from going on. So far as we know, all the noxious emanations from organic matter arise during the decomposition of the organic matter. Whenever the organic matter begins to decompose, the parts of which it is composed are separated and come out in forms which are hurtful to health, but we can prevent this decomposition going forward. We can prevent the formation of those gases or vapours which are injurious to health.

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I have had considerable experience with regard to the sewage of towns and as to preserving those matters in such a condition that they shall not be offensive by giving off emanations into the atmosphere, and that they shall be so preserved that their value as manures will not be diminished, and I find that these two important results may be obtained simply by the use of antiseptics. They are becoming, for this reason, very much used in farm-yards, in stables, and cow-houses by farmers generally. It is found that the great loss which is caused by the decomposition of the manures is thus obviated. The manure can be preserved for many months in a condition as sound as it was at the beginning, and at the same time it is found that a manure so treated does not give out any offensive smell : the animals, therefore, which are otherwise continually exposed to foul emanations, are preserved in very much better health. I could give many instances proving that animals are preserved, by this means, from disease, but it would probably be tedious to give them. The country generally is scarcely aware how much this sub-

ventilated through charcoal disinfectors, a plan which is found to answer admirably in Europe.

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ject has been cultivated in some parts of it, and how largely farmers and keepers of horses are becoming acquainted with the value of disinfectants for the preservation of manures, and for the preservation of the health of animals, nor is it aware that, whilst the health of the valuable animals is preserved, the destruction of the lower forms, such as insects, grubs, &c., is at the same time secured.

It was in pursuit of this enquiry that Mr. McDougall and I performed some experiments at the desire of the Board of Works upon the treatment of sewage in the same manner, in order to prevent decomposition in the sewers, and mainly, perhaps, also to preserve the manure matter untouched. We took specimens of the sewer water disinfected and not disinfected, and kept it for various periods of time, one, two, three and four days, weeks, and months, and we found invariably that if enough were added of disinfecting matter there was no emanation of gaseous matter from the sewer water, and that, in fact, the sewer water could be completely prevented from decomposition by the use of a very small quantity of the disinfectants. It was proposed by me, although it did not receive any attention, that these disinfectants should be applied to the sewers themselves, instead of allowing the putrid matter to flow through cities in many of the streets, and that we should pour the disinfecting materials into the sewers and prevent the formation of those gases at once, instead of allowing them first to form, and then endeavour to put them away. * * *

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Q. Is it the fact that this disinfecting fluid (McDougall's powder) does not at all deteriorate the value of the sewage matter as manure?

A. On the contrary, I am endeavouring to show that it preserves its value and prevents decomposition.

Q. Then it is equally good as manure after the mixture has taken place with the disinfecting fluid as it was before it?

A. Yes, decidedly so. * * * * *

Q. Did he (Mr. McDougall) not offer to disinfect the Thames for a certain sum of money?

A. I do not know that he made that offer, but he gave reasons for his belief that it could be done for a certain sum.

Q. Can you state what that sum was?

A. I think it was at first about £15,000 a year if continued during the whole year: but that would have disinfected not only the Thames, but the whole of the Metropolis, all the sewers and the streets, and the Thames besides.

Q. Do you think that that was a reasonable sum to name as the probable expense?

A. There might have been perhaps a few thousands to be added to that, making the sum possibly £20,000 if it were used for the whole year: but as it would require to be used for only a part of the year, the first sum is probably too large, or at least abundant."—*Vide Page* 155, *Vol. I of the "Report of the Commissioners."*

Why sewers cost more than ordinary masonry works.

It may be asked, "if sewers can be thoroughly disinfected, what is the use of placing them so deep underground?" And it has been suggested, that the modern system of sewers has been devised by the Engineer to "afford him the opportunity of dealing with magnificent estimates." This is an unfortunate reason to adduce in this country, where Engineers, instead of receiving a percentage on the outlay, have their projects returned on their hands unsanctioned, if the cost is at all considerable. The truth is, that there are very few places where sufficient fall can be obtained for sewers to prevent their becoming choked up, without creating it artificially. This is why sewers cost more than ordinary masonry works.

These are all the objections known to me which can be urged against sewers, and I trust they have now been fully answered. In bringing them forward, however, Doctor Cornish has illustrated the evil of sewers by two examples, viz., Bombay and Calcutta. It is necessary that these cases should be gone into.

Sewers of Bombay.

Of the sewers of Bombay, the only faults that can be found are that "the sewage is proposed to be turned into the harbour for the benefit of the shipping,"* and "that there is not the smallest probability of the works being, in the remotest sense, of a reproductive nature."* Now, a glance at a map of Bombay will show how wisely the plan of sewerage has been designed. Bombay stands on the extremity of a long island, the margin of which nearly all round is elevated over the central portion which is an unhealthy salt-water marsh *lying below high tide level.* The elevated is the inhabited portion of the island. Now, to make use of sewage, it would be necessary, in the first place, to reclaim the swamp at great cost, and, in the second place, it would be fraught with the greatest danger to the inhabitants. To carry it to the mainland by sewers would cost so much that the works could not be made remunerative. The sewage

* Vide Page 23 of Doctor Cornish's Pamphlet.

is, therefore, discharged into the sea in that direction from which the wind blows least often in the year. To complain, then, that sewers are objectionable because a town, which has no land on which it *could* safely utilize its sewage, does not do so, is surely very unreasonable.

Sewers of Calcutta.

Now, with reference to Calcutta, the case is much worse. Doctor Cornish says,* "Mr. Strachey, in his late Minute on the sanitary condition of Calcutta, with its underground sewers, has declared it to be the most filthy of the filthy cities of the world." I give, in a note, Mr. Strachey's Minute entire, from which it will be seen that so far from Mr. Strachey saying that *sewers* are the cause of the filthy state of Calcutta, his words are†—"This

* Vide Page 8 of Doctor Cornish's Pamphlet.

† *The Conservancy of Calcutta and Towns in the North-West contrasted.*—"It is not my wish to describe in detail the condition of Calcutta. To all who are here upon the spot, the facts are notorious. The state of the Capital of British India, one of the greatest and wealthiest cities in the world, is a scandal and disgrace to a civilized Government. The questions that are involved are not mere questions of ordinary sanitary improvement, such as those which commonly arise in other cities and in other countries. The condition of this City is such that it is literally unfit for the habitation of civilized men. Even if we put aside all questions of public health, and look on the matter as one of common decency, or as one of good goverment, the state of Calcutta is disgraceful to the last degree.

It cannot be too prominently stated that the condition of Calcutta is not the normal condition of Indian cities. I have seen the most important towns of the North-Western Provinces, of the Punjaub, and of the Central Provinces. Their sanitary state is doubtless often in many respects most objectionable, but in comparison with Calcutta they are really almost faultless. There is no apparent reason why the difficulty of keeping Calcutta in at least a tolerable state of cleanliness should be greater than that experienced in other Indian cities. It is true that Calcutta is larger, but, on the other hand, it is incomparably richer, and it possesses greater natural facilities for carrying out a proper system of conservancy than any which exist in the cities of Northern India. Even, however, if it should be considered that the difficulties of cleaning Calcutta are greater, there is certainly no necessity that there should be such an extraordinary difference as that which actually exists.

It is often said that nothing effectual can be done for the purification of Calcutta until the great system of drainage now in progress is brought into operation. In reply to this, it appears to me quite sufficient to point to the fact that the cities of Northern India are kept in a state of at least tolerable cleanliness, and free from

state of things appears to be mainly the result, not of the absence of properly constructed works of drainage and of public convenience, *although such works are doubtless most urgently required*, but of the almost *total neglect of the ordinary every-day operations of conservancy*,"—a very different thing altogether! It is manifest, too, that a system of drainage, which is now only "*in progress*" according to Mr. Strachey himself, and has not not yet been "*brought into operation*," cannot be the cause of a state of things already existing. And Mr. Strachey actually advocates the construction of sewers, so that the President of the Calcutta Sanitary Commission cannot think sewers objectionable.

But Doctor Cornish says,—"As regards the Calcutta scheme, there are not wanting men of eminence in sanitary knowledge who have from the first prophesied its ending in a gigantic failure,"* and he refers the reader to Doctor Norman Chevers' Minute on the subject, which again I have thought it best to

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all, especially disgusting, nuisances, without any such system of scientific drainage. What is possible there is beyond the slightest doubt possible here also.

So far as the theory of the conservancy of Calcutta is concerned, there seems, in the present absence of properly constructed drains, comparatively little to find fault with ; but the practice is something very different from the theory. Thus, for example, the whole of the solid portions of the filth of the city is supposed to be carried away every day. But, in fact, throughout the greater part of the native quarter of the town, nearly all the night-soil and other filth from the houses runs, or is thrown, into the open drains on the sides of the streets, and, since these drains have generally little or no fall, the greater portion of the filth remains there. It is no exaggeration to say that the most important streets and thoroughfares of the northern division of Calcutta form, to all intents and purposes, a series of huge public latrines, the abominable condition of which cannot adequately be described.

This state of things appears to be mainly the result, not of the absence of properly constructed works of drainage and of public convenience, although such works are doubtless most urgently required, but of the almost total neglect of the ordinary every-day operations of conservancy."—"*From a Minute by J. Strachey, Esq., President of the Bengal Sanitary Commission, dated 5th March* 1864." Vide Page 26 of Doctor Cornish's Pamphlet.

* Vide Page 23 of Doctor Cornish's Pamphlet.

give entire.* From a perusal of this paper, it will been seen that Doctor Chevers makes no objection whatever to the *sewers*, but

* *The Drainage of Calcutta.*—"Calcutta is a city built in a rice-field, which is another word for swamp, or place in which all malarious venoms,—ague, dysentery, asthma, cholera,—breed eternally, until thorough drainage breaks up their nests. This may be said of nine-tenths of the other towns in Bengal Proper, but we have close beside us a cause of destruction which they have not—a vast salt lagoon hemming us in landward and poisoning every breath of cool air which comes to our greedy lips from the always unwholesome East. By what appears to me the greatest and most calamitous sanitary blunder on record, it occurred to the minds of the Drainage Commissioners of 1857, to utilize this 'Dismal Swamp,' this 'Slough of Despond,' reeking with marsh damps and with the decomposed elements of myriads of dead creatures which, in deference to an esteemed friend and brother sanitarian, I must say do not stink, but send up continually, to use an opposite quotation of his own, 'an ancient and very fish-like smell.' It occurred, I say, to these Commissioners, that the waters of this salt swamp robbed the breeze of its malaria, as those of rivers and sea estuaries do, and that, because salt preserves meat, these brackish waters would have the power to disinfect the whole sewage filth of this city, which is, accordingly, to be voided into them!

The gentlemen who made this frightful mistake are good men and true, whom I heartily honor; but, to say nothing of a host of authorities in modern times, there has been no English physician, since the days of Queen Elizabeth, who would not have told them that the most pestilentially deadly of all swamps are those which contain salt water. * * * * *

The drainage system ought, on no account, to include the removal of fæcal excreta by the sewers. The whole of the bath-room and tatty excreta should be removed by a system of conservancy. The present tatty arrangements should be thoroughly re-organized. Those public necessaries which now occupy objectionable sites should be removed, and latrines nearly like those first introduced at Agra should be established in comparatively safe and open situations. The whole ordure of the city should be removed, nightly, in well-constructed trapped iron conservancy carts, drawn by horses. * * * * *

The feculent excreta and every kind of solid filth, road scrapings, and sweepings, stable-litter, the refuse of knackeries, markets, tan-yards, urinaries, gardens, cook-rooms, &c., &c., &c., being collected and carried away in conservancy carts, the fluid sewage of the city, that is, all liquid matter from manufactories, markets, gas-works, cook-rooms, &c., &c., which could not be removed in conservancy carts, being properly diluted and flushed onward with an abundant supply of fresh water, at high pressure, should be voided by a system of underground sewers of very moderate capacity, the inlets of which ought to be secured against the entrance of storm-water and of all solid refuse, while the whole rain-water, except such portion of it as may be required to flush the sewers, &c., should be carried off by a system of open surface-drains."—"*Doctor Norman Chevers*' Indian Annals of Medical Science, No. XVII., Page 63." Vide Page 37 of Doctor Cornish's Pamphlet.

simply to the outfall being placed in a salt marsh.* Indeed, he, like Mr. Strachey, *advocates* the sewer system, and, as I consider, lays down the true principles on which drainage in this country should be carried out. He says :—

"The feculent excreta and every kind of solid filth, road scrapings, and sweepings, stable-litter, the refuse of knackeries, markets, tan-yards, urinaries, gardens, cook-rooms, &c., &c., &c., being collected and carried away in conservancy carts, the fluid sewage of the city, that is, all liquid matter from manufactories, markets, gas works, cook-rooms, &c., &c., which could not be removed in conservancy carts, being properly diluted and flushed onward with an abundant supply of fresh water, at high pressure, should be voided by a system of underground sewers of very moderate capacity, the inlets of which ought to be secured against the entrance of storm-water and of all solid refuse, while the whole rain-water, except such portion of it as may be required to flush the sewers, &c., should be carried off by a system of open surface drains."

Thus, it will be seen that the very two witnesses whom Doctor Cornish brings forward to prove that there should be no sewers, give the strongest evidence against him. One, Mr. Strachey, says,—"drainage works are urgently required," and the other, Doctor Chevers, points out how the "underground system of sewers" should be constructed. The case against sewers, therefore, so far from being made out, utterly falls to the ground.

Dr. Chevers' views on drainage.

I beg respectfully to draw the attention of Government to Doctor Chevers' views on the subject of drainage as meriting great consideration at the present time. I believe them to be the true principles on which drainage works in this country should be carried out, and the only broad principles on which success can be ensured at least cost. I arrived at the very same conclusion as Doctor Chevers has done very soon after I commenced the preparation of this project for the drainage of Madras, and, further on in this Report, I have brought forward

* It would be no argument against railways generally, if some one should propose to carry one from Madras to the brackish swamp near Ennore.

all the facts which I had collected to show the difficulty of following the English plan of sewerage, in Madras or in those parts of the Presidency where the total rainfall was obtained in a few days, and the enormous expense it would entail. The proposition now made for the drainage of Madras, viz., to separate rain-water from sewage—to carry away the former by open surface drains, and the latter by sewers of moderate capacity, will, I trust, be received by Government with greater favour, now that it is put forward by an eminent man, than if it had been made by myself alone.

The advocates of dry conservancy propose to dispense with sewers altogether.

But, it may be thought that a very simple answer to all that has been said regarding sewers may be made by the advocates of dry conservancy. "We do not object to sewers but only to *costly* works of drainage." Although such an argument would be very absurd, simply because all works of town drainage must be costly, still some attempt at a compromise might have been expected in the matter, but so far from this, it is insisted that the question of cleansing towns is one simply of dry conservancy, *or* sewerage—either one or the other—that it cannot be partly of both. The following passage will render this clear:—

"The truth is, that even if a thorough system of drainage, as in European countries, were advisable, the practical application of the principle would be attended, in the Peninsula of India, by difficulties insurmountable."*

If insurmountable practical difficulties are urged against a *thorough sewer-system on the European model*, *i. e.*, on the most scientific principles known to Engineers, how great must be the difficulties attending a partial or incomplete system of drainage, and what folly it would be to attempt to carry out such a system? It follows, therefore, that the advocates of universal dry conservancy will admit no compromise in the matter. In fact, they desire that the question should be settled by a decision of Government as to whether they will have dry conser-

* Vide Page 6 of Doctor Cornish's Pamphlet.

vancy only, or drainage by sewers only. That the former alternative is impossible, I trust it has already been proved. That the latter is possible, is proved by the hundreds of instances in which it has been most successfully carried out.

The originators of dry conservancy admit the necessity of sewers.

It is easy to see how, in bringing forward the dry system for adoption in Madras, its advocates have been led into their great error. The two gentlemen—Dr. Thudichum and the Rev. H. Moule—who have directed attention to the subject in England, were charged at a Meeting* of the Society of Arts, when the question was discussed, with the intention to interfere with sewer drainage. Immediately after the discussion, Dr. Thudichum, to whom this intention was attributed, perhaps unfairly, said, in reply :—

"Regarding the allegation that his plan would produce nuisance and *interfere with the proper working of the sewers*, he should certainly blush if such an imputation could be brought successfully against him, for he claimed to be a physician and a chemist."†

It is clear, therefore, that Doctor Thudichum does not propose that his plan shall in any way supersede sewers.

The Rev. H. Moule, too, who had fairly brought the charge upon himself by using unnecessarily vehement language, and by declaring openly that "no public works were required," found it necessary to retract, and said that—

"He had throughout disclaimed having anything to do with London or towns where there were water-works. But his field of operation was vastly wider than that. He contended that the Board of Health too much overlooked the country districts. The cottages were detached but *wholly undrained*."‡

This is practically conceding the whole point at issue, for Mr. Moule disclaims any intention to apply the system of dry conservancy to towns having a water-supply. Now, every town sooner or later must have its water-supply, and it is the great necessity

* Twenty-second Ordinary Meeting, May 13, 1863.

† Vide Page 451, Vol. XI., of the "Journal of the Society of Arts", for May 15, 1863.

‡ Vide page 452.—*Ibid.*

of Madras. Mr. Moule, moreover, wishes to apply dry conservancy only to localities which are wholly undrained—in fact, dry conservancy, as proposed by him, is merely a temporary measure to be adopted only until the neighbourhood becomes sufficiently important to have its system of water-supply and drainage. No one can object to dry conservancy on such conditions. But by not keeping carefully in view the objects proposed by the originators of the dry system, its advocates in India have made the capital mistake of supposing that the removal of excrementitious matter is all that is required to keep our towns clean and their inhabitants healthy. If a thousand model latrines were to be built in Madras immediately, the state of the streets would not be in any way affected by them.* The drains would be as offensive as they now are, and the people would be burdened with the cost of an experimental system of conservancy which, by absorbing all their funds, would effectually put a stop to all works of real improvement.†

* Some of the most disgusting and filthy neighbourhoods in Madras are well furnished with privies.

† Throughout this Report I have argued the question of "Universal Dry Conservancy or Sewers" as against Doctor Cornish, considering that, by the publication of his Pamphlet on "The Cleansing of Towns," he has, as it were, constituted himself the exponent and advocate of the former system in Madras. And while doing so, I have at the same time endeavoured to meet all the objections to sewers which I have heard or seen stated by those who have adopted the new theory. Having been entrusted by Government with the preparation of a project for draining the town, I have felt it incumbent on me to go into the question of dry conservancy very fully, as my silence on the subject might have been construed into an admission on my part that drainage by sewers was not the best—the *only* means of cleansing the town. I am not aware that any other gentleman besides Dr. Cornish has really proposed to dispense with sewers.

CHAPTER V.

DESCRIPTION OF THE PROJECT.

Outline of the Project.

It is proposed to drain Madras from the south to the north—to separate the sewage from the rain-water—to carry the former by sewers of small capacity to *one* central spot, north of, but near, the Madras Railway, and in the neighbourhood of the village of Coorookoopett—to lift it there by steam pumps—and, according as Government may decide, either to discharge it by an outfall sewer into the sea at a point two miles north of the Railway, or to utilize it on some thousands of acres of waste land lying to the north-west of Madras.

In order to render the description of the Project clear, I shall, for the present, defer the consideration of the proposition to utilize the sewage for agricultural purposes, and treat the subject of drainage as if it were necessary to take the sewage away from Madras altogether.

The outfall.

The first point to settle in every project for drainage is the locality of the ultimate outfall for the sewage. Everything hinges on this. At present the sewage of the town, as before mentioned, is discharged partly into the Cooum, partly into the Canal, and partly into the sea; and these are all the outfalls available for Madras. The evil of polluting rivers with the filth of cities has grown to such great proportions in England, and is so fully recognized by all classes, that attempts have lately been made to place the conservancy of all rivers in the United Kingdom in the hands of a Controlling Board. It is unnecessary for me to dwell on the present disgusting state of the Cooum or on that of the Canal. To say that they are mere cesspools, from which the sewage cannot possibly

No sewage should be discharged into the Cooum or the Canal.


Madras Drainage.
MAP
of
MADRAS
SHOWING THE LINES OF SEWERS
PROPOSED TO BE LAID DOWN.
PROPOSED SEWERS
PRESENT SEWERS
MAIN LINE
BAY OF BENGAL

escape, is to bring the subject with sufficient clearness even to the minds of those who have never visited Madras. It should be an indispensable condition of every project for draining the town that the Cooum and the Canal should not be converted into sewage reservoirs. Until this is acted upon, all attempts to render Madras healthy must necessarily be only partially successful.

The sea, the best outfall, but no sewage should be discharged near the town.

The only outfall, then, left for consideration, is the sea. The abominable stench from the mouth of the sewer at the north-east angle of the Fort, which drains a portion of Black Town only, is convincing evidence that it is not sufficient merely to discharge the sewage into the sea. No description can convey to the minds of those who have never lived within the influence of the smell from this sewer, its overpowering offensiveness while the outlet is open. The Fort would hardly be habitable from October to February, or while the north-east winds prevail, if this outlet were kept open during the whole day. Fortunately, the sewer is large enough to hold all the sewage which flows into it, for a day or two, so that it is unnecessary to open the mouth except for about a couple of hours during the night. This is done, too, at a time when the wind is blowing from the west in order that the smell may be driven out to sea.

In some instances in England, no nuisance arises from the outfalls of sewers being placed on the coast and opposite to towns. But this is due to causes which do not prevail in Madras. In England, the tides rise and fall considerably. In London, the difference between low and high tide is 20 feet—in Liverpool, it is 32 feet—in the Bristol Channel, as much as 47 feet. The velocity of the ebb stream, or that which conveys the sewage away from the coast is, under these circumstances, very great. But in Madras, the tides rise and fall three feet only, and the water is exceedingly shallow. The consequence is, that the velocity of the ebb stream is trifling, and the sewage keeps floating by the coast instead of being carried out to sea

at once. The prevailing currents, too, for 10 months in the year, follow the line of the coast, *i. e.*, run north and south. Sewage, therefore, discharged opposite the Fort, flows directly in front of Black Town or Triplicane, the two most important, because the most densely populated, neighbourhoods of Madras.

The nuisance at present from the drain near the Fort is as nothing compared with the nuisance which would ensue, if the main outfall for the drainage of the entire town were situated in the same locality. Under the present imperfect arrangements for drainage, the quantity of sewage which ultimately reaches the sea is small, and it is sufficient if the mouth of the main discharging sewer is opened occasionally. But under a complete system of water-tight sewers, and street and house pipe-drains, the quantity of sewage would be considerable, and it would be impossible to pond it up for many hours together without incurring great expense. The line of coast, too, for a quarter of a mile or so on either side of the outfall, would be so covered with filth of every description, that the sea breeze, instead of being, what it now is, a great source of health to the inhabitants of Madras, would be deprived of all those pleasant associations which we at present connect with it. No outfall so situated as to contaminate our sea breeze should be permitted.

If this is granted, it follows that no sewage should be discharged on the sea-board of Madras Proper, *i. e.*, within the limits of the inhabited strip of coast land from Royapooram in the north to St. Thomè in the south. Government should insist on this. The question, therefore, so far as the outfall only is concerned, resolves itself now into this, "Shall the sewage be carried into the sea north, or south, of Madras?" In order to decide this satisfactorily, several points should be considered. "Is the town with regard to its physical features more favorably situated for a southern or for a northern outfall?" "What is the direction of the prevailing winds?" "What that of the

prevailing sea current?" "What particular advantages does a northern or a southern outfall offer in itself?"

Position of Madras renders a northern outfall necessary.

The most important of these considerations is, without doubt, that which relates to the general configuration of the ground on which the town stands. Now, it has already been explained that, practically, there is no natural line of drainage for Madras, considered as a whole. But if this point admits of dispute, then the only line of drainage, which it is possible to call such, is the valley along which the Canal runs. And, certainly, although the greater part of Black Town and all Royapooram drain into the sea, yet the portion of Madras lying to the north of the Cooum may, in some respects, be considered as two slopes of ground inclining towards the Canal. The fact, too, of the districts south of the Cooum being generally on a higher level than the valley itself, may strengthen this view—viz., that there is a natural drainage line. But this very fact shows that the southern portion of Madras, if it is the higher, must be drained towards the north, *i. e.*, if the valley of the Canal is taken as the drainage course. And the northern portion cannot be drained to the south, because, in that case, the outfall into the sea must be situated somewhere between Triplicane and Black Town, which, it has already been shown, would be highly objectionable, because the sea breeze would be contaminated. The only course left to adopt then, is, to drain the whole of Madras to the north. And this is exactly what is proposed to be done. So far then as the question is affected by considerations of the natural position of the town, the advantage of the northern outfall is clear and decided.

The situation of the outfall considered with reference to the winds.

Now, with respect to the winds, the situation of the two outfalls is about equally favourable. The prevailing winds* are those which blow between south and west, and these winds in *either* case would convey the smell of the sewage out to sea.

* Vide "Chart showing the number of days in the year the Wind blows in Madras from each point of the Compass," which faces page 109 of this Report.

The winds, which would bring the smell into Madras, are, in the case of a northern outfall, those between N. N. E. and E. N. E., and, in the case of a southern outfall, those between S. and S. E. Both the former and the latter blow for about 80 days in the year.

Sea currents render a northern outfall necessary.

With reference to the sea currents, the advantage lies decidedly with the northern outfall. The current which flows from the north southwards begins about the middle of October and ends in February, or runs for about 4½ months in the year. This current would, in the case of a northern outfall, bring the sewage in the direction of Madras, and, in the case of a southern outfall, would carry it away from Madras. The current which flows from the south northwards begins in March and ceases in August, or continues to flow for about six months. During the remainder of the year, *i. e.*, in September and the first half of October, the prevailing winds are from the south, and if, as is most probable, the currents run in the direction of the wind, this second current will have a northerly direction. Thus, for about 7½ months, the northward current would, in the case of a northern outfall, carry the sewage away from Madras, while, in the case of a southern outfall, it would bring it to Madras. There is no doubt, therefore, that, so far as the currents of the sea are concerned, the outfall should be placed to the north of Madras.

Special advantages of a northern outfall.

The special advantages which the northern outfall offers are very great. There are no Engineering difficulties to be overcome in the construction of the works, or to render them expensive. If the sewage were taken to the south, the outfall should be placed at least one mile south of St. Thomè, in order to prevent any nuisance to the inhabitants of this locality. This would make it necessary to carry the sewage either by a tunnel beneath the river Adyar, or by an aqueduct over it. Either of these works would cost a large sum

of money. In the south, the sewage could not be utilized for agricultural purposes so judiciously as in the north, for the prevailing winds would blow the smell to the town. The lands, moreover, are not well situated, whereas, in the north, there are upwards of 20,000 acres of waste ground situated on the most favourable level possible, and in the direction from which the wind blows least often during the year. All these considerations render it advisable to adopt a northern outfall for the drainage of Madras.

How far north should the outfall be placed?

Having settled this point, it next becomes necessary to decide *how far* north the sewage should be discharged. And this admits of some difference of opinion. The arrangements made in this Project are to place the outfall, *for the present*, at a point 2 miles north of the Railway Station. This is $1\frac{1}{2}$ miles from the nearest dwellings in Royapooram. I believe no nuisance will arise from this arrangement. When the northerly current is running, the sewage will have flowed a distance of more than two miles before it comes opposite to the nearest part of Black Town. Should it, however, be found hereafter that the outfall is not far enough away to the north, I have arranged so that it may ultimately be removed to a point 3 miles north of the Railway. Without positive evidence that the outfall at this distance would prove a nuisance, it would not be desirable to place it higher up on the coast. The question is one of expense only, for, so far as the Engineering difficulties are concerned, it would be as easy to carry the sewage 4 miles to the north as to discharge it where it is now proposed to place the outfall.

Impossibility of draining Madras by gravitation.

Having now arranged about the direction in which Madras is to be drained, and the distance from the town at which the outfall should be situated, the next question requiring an answer is, "Can the sewage be discharged into the sea simply by gravitation, *i. e.*, without lifting it at any intermediate point between the town and the outfall?" An examination

of the Map of Madras,* which accompanies this paper, should convince any one that this is impossible. The present system of open drains is a practical attempt to answer this question in the affirmative. But what the effect is, Government know well. Hardly a single drain has sufficient fall to keep itself free from deposit, and the consequence is, that the work which the drains should do, has to be done by the scavengers of the Municipal Department, and at a tremendous cost to the people. It is, indeed, impossible to drain a place like Madras, which covers 27 square miles of country, and many parts of which, in all quarters of the town, are elevated from 3 to 6 feet only above the sea, by simple gravitation, and without raising the sewage artificially. A great deal has been written and said about the expense of pumps, but those who object to them forget that there is only one alternative for them to adopt. That is, to lay down their sewers either at a dead level, or at a slope which, to all practical purposes, is no better than a dead level. I think I can render this very clear.

The lower parts of Tondiarpett, Royapooram, part of the valley of Black Town along Popham's Broadway, and of that to the west of the Canal, parts of Pursewakum, Veyasurpady, Perambore, Vepery, Chintadrapett, and of the District between Triplicane and St. Thomè, are from 3 to 6 feet above the sea. How can all these neighbourhoods be connected together by any system of sewers, and the sewage be discharged into the sea by gravitation? Take the single neighbourhood of Pursewakum. It is two miles from the sea. There is a valley half a mile long, running east and west through it, which is in some parts 6 feet and in others only 3 feet above the sea. There are portions of the surrounding neighbourhood, moreover, which are half a mile distant from the valley and only 8 feet above the datum line. Now, the street drains from these places down to the sewer in the valley, should be laid at such

* Vide also "Map of Madras," facing page 75 of this Report.

inclinations as will keep them clear of deposit. Suppose they are 9-inch pipes. These should be laid at a slope of at least 1 in 250. As they would be half a mile or 2,640 feet long, the total fall required for them would be $\left(\frac{2640}{250} =\right)$ at least 10 feet. If they were 6-inch pipes, the total fall required would be about 18 or 20 feet. But if the lowest part of the valley is 3 feet above the sea, and the streets, half a mile distant, 8 feet only above the sea, the total fall available is only 5 feet. And after the sewage had been collected in the valley, it would still have to be taken 2 miles to the sea with a fall of only 3 feet, and, in its course, it would have to cross the canal, the water in which is at a dead level with the sea. How could pipes or sewers on such a system of slopes keep themselves clear of deposit. It is utterly impossible to drain Madras into the sea without first raising the sewage by artificial means.

Position of pumping station.

If this, then, be admitted, the next point to settle is, "Where shall the sewage be pumped up?" This is almost altogether a question of Engineering. If the ground were very favourable, *i. e.*, if the soil were hard and there were no water to interfere with the construction of the sewers, it might be best to take the sewage right away to a spot near its ultimate outfall on the coast, and to pump it up there at once into the sea. But this is not the case. The strata beneath the surface soil consist chiefly of sand, and water is found in almost all parts of Madras at about the sea level. It becomes, therefore, positively necessary to raise the sewage at some intermediate point. I have selected a point very near the Madras Railway, but lying to the north of it and in the neighbourhood of the village of Coorookoopett. This will necessitate the construction of a tunnel under the Railway. But a tunnel would have been necessary, even if the site for the pumps had been to the south of the Railway; for the sewage of Tondiarpett and of the neighbourhood to the north of the Railway must, in that case, have been brought to

the site by a tunnel crossing the Railway. It will thus be seen that, under any circumstances, a tunnel was unavoidable. The site selected for the cesspool and pumps is situated in that quarter of the town from which the wind blows least often in the year, and it is near the lands on which it is proposed to utilize the sewage.

The pumping should be concentrated at one point.

I have considered whether it might not be advisable to have two cesspools and two sets of pumps—one for the portion of Madras lying to the north of the Railway, and the other for that lying to the south of it. But the first cost of such an arrangement would be even greater than that of the tunnel now proposed, and the working expenses of such a system of sewerage would be nearly double that in which all the pumping work was concentrated at one point.

I trust that it has now been satisfactorily shown that Madras should be drained towards the north,—that (putting aside for the present the question of utilizing the sewage) the best outfall is the sea,—that it will be sufficient if the outfall is placed on the Coast 3 miles north of the Railway,—that it is not possible to drain the town by gravitation,—and that, consequently, the sewage must be pumped up at some intermediate point between the town and the ultimate outfall.

Sewage should be separated from rain water.

So far, this Project does not differ from the system of drainage adopted in many towns in England. I beg now to draw the attention of Government to a point which appears to me to demand the greatest consideration. In England, it is usual to have one and the same system of sewers to carry off both rain-water and sewage. I propose, however, that in Madras, sewage shall be carried away by a system of underground sewers and pipes of very small dimensions, and that rain water shall be removed by a system of open surface drains unconnected with the underground sewers and pipes. To justify such a departure from the stereotyped system of sewerage which has the

sanction of European engineers, it will be necessary that full and sufficient reasons should be given.

In designing sewerage works, the dimensions of the sewers are regulated almost entirely on considerations of rainfall. The sewage proper forms so small a proportion of the total amount of fluid matter to be removed, that if a sewer is large enough to discharge the rain which falls on the district for the drainage of which it is constructed, it is hardly worth while to consider the small quantity of sewage which may flow into the sewer. In fact, sewers in England are constructed, *first*, for the removal of the rainfall, and then for the removal of the sewage.* In a country, however, like England, where the rainfall is pretty evenly distributed through all the months of the year, and where there are no extraordinary falls of rain such as we so often have in India, this principle of carrying off both rain water and sewage by one set of channels is not perhaps objectionable. It rains off and on throughout the year. Sometimes for days together there is no cessation at all. The consequence is, that the amount of water in the sewers does approximate to *some* extent to a constant quantity. In heavy rainfalls the amount is somewhat in excess of this quantity, and in light rainy weather it is somewhat below it.

The rainfall in England and in Madras contrasted.

But in India the conditions of rainfall are totally different to those in England. In the first place the yearly rainfall in India is double that of England. And while in England the supply is received in small monthly instalments all the year round, the supply in India is often received in 10 or 12 days only.

The accompanying diagram has been prepared with the view to explain the extraordinary difference between the rainfall in

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* In London the sewage proper is calculated at about 1-5th of the ordinary rainfall.— *Vide Page* 305 *of Neville's Hydraulics.*

England and in Madras. The first fact to which I beg to direct the notice of Government is the marked evenness of the line which represents the "mean" rainfall in England.* The greatest difference in the quantities of rain which fall in any two months is between those which fall in April (about $1\frac{1}{2}$ inches) and in November (about $3\frac{3}{4}$ inches). But even this difference amounts to only $2\frac{1}{4}$ inches. So evenly distributed is the rainfall, that if it were said of England that the quantity of rain which falls in every month of the year is 2 inches, there would really be no great error made.

The second fact to which I would draw attention is the parallelism between the thick and thin red lines. The former shows the maximum quantity of rain that has been known to fall in England in each month of the year. It runs throughout about two inches above the thin line and thus indicates that the maximum quantity of rain in each month is 2 inches only more than the mean quantity.

Now, let me turn to the rainfall in Madras, the yearly quantity (about 50 inches) being double that of London (about 25 inches). The thin blue line represents the mean rainfall of 20 years' observations. It will be seen that in the first four months of the year there is, practically speaking, no rain at all—that in the next 5 months the rainfall is only slightly in excess of that of England—but that in the months of October, November, and December, it is considerably in excess of it. Now, if sewers are to be constructed for the removal of rain water, it is very evident that in Madras they must be large enough to discharge the rainfall in the months of October and November, when the heaviest quantity of rain descends. Suppose that the dimensions of the sewers in Madras are regulated by comparison of the mean monthly rainfalls in London and Madras. Then, the mean rainfall

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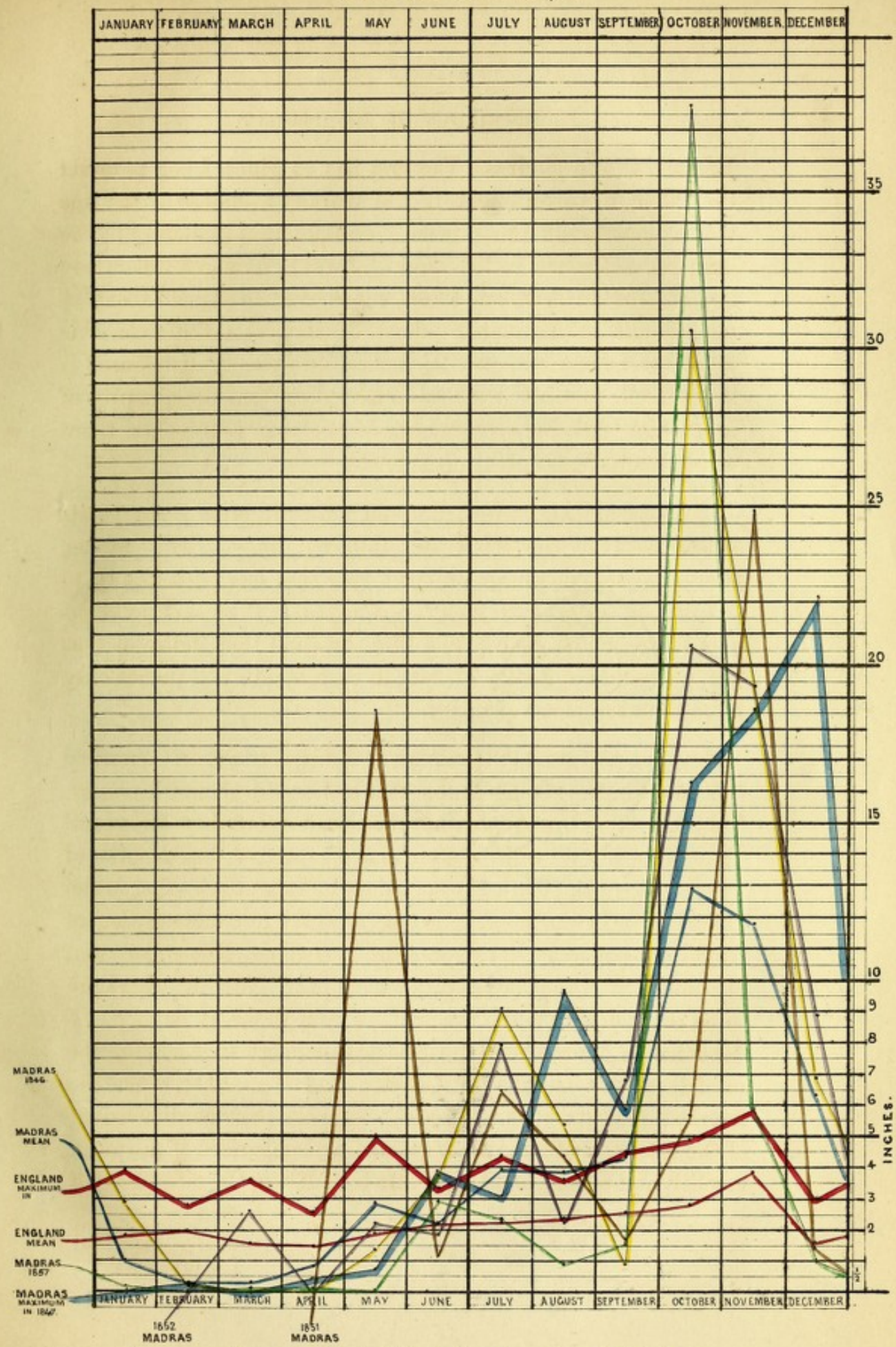
* Vide Page 311 of "Neville on Hydraulics."

Madras Drainage.



Monthly Rainfall in England and Madras.

A. BARREN. LITH. JAN. 1865.

H. YULLOCH. DEL.

in Madras in October (about 13 inches) being more than 3 times the mean rainfall in London in November (about 4 inches), it is evident that the sewers must have three times the discharging capacity. A single mile of sewers laid down on this principle would cost more than the entire project now submitted to Government.

The difference between the maximum monthly rainfalls in Madras and in England is even still greater than that between the mean monthly rainfalls in the two places. The maximum quantity which has fallen in one month in England is, as shown by the thick red line, nearly 6 inches. But the maximum in Madras is, as shown by the green line, nearly 38 inches or upwards of 6 times the maximum of England.

Together with the mean and maximum monthly rainfalls in the two countries, I have projected on the accompanying diagram the monthly rainfalls in Madras of some of the most interesting years. From these it will be seen that it is far from an unusual occurrence to have upwards of 20 inches of rain in a single month of the year.

If we compare the *daily* rainfall in England and in Madras, the difference becomes still more striking. The following are the greatest daily rainfalls in England of which I can find any record :—

Locality.	Date.	Rainfall in 24 hours.	Remarks.
		Inches	
Little Bridy Dorsetshire	July 1858	2·06	Vide page 332 of "Beardmore's Manual of Hydrology."
Oxford	July 1853	1·82	Vide page 333, *Ibid.*
Wandsworth	12th June 1859	2·17	Vide page 293 of "Neville's Hydraulics." This fell in two hours.
Manchester	7th Aug. 1859	1·849	Do. do.
Southampton	26th Sept. 1859	2·05	Do. do. This fell in 2¼ hours.
Truro	25th Oct. 1859	2·4	Do. do.
Holborn	1st Aug. 1846	4·00	Do. do. These quanties are stated to have fallen in one hour.
Highgate	Do.	3·5	
Greenwich	Do.	·95	

The following is a table of some of the heavy daily rainfalls in Madras in the years from 1822 to 1857 :

Date.	Rainfall in 24 hours.	Remarks.
	Inches.	
4th November 1822	7·88	
29th October 1825	8·87	
9th May 1827	12·08	
27th November ,,	7·77	
31st October 1836	7·50	This fell in the night only.
20th November ,,	9·65	
27th December 1845	7·20	
21st October 1846	20·58	
4th May 1851	11·45	
4th November ,,	7·90	
20th November 1856	6·22	This fell in 5 hours.
24th October 1857	18·04	Before sunrise 5·83 inches—before sunset 12·21 inches.

It will thus be seen that while 4 inches is the utmost that has been recorded to have fallen in England during the day, upwards of 20 inches have been known to fall in Madras in the same period of time. How could Madras afford to pay for sewers constructed to discharge five times the quantity of water which the London sewers discharge ?

The very mode in which the monsoon in this country comes down renders it difficult to provide underground sewers to carry away all the water. It is well known that a tremendous storm of rain of short duration, *i. e.*, for an hour or so, is not nearly so trying to sewers as an ordinary storm continued over several hours. In a storm of an hour or so, the whole of the rain cannot reach the sewers until some hours after the storm has passed ; the consequence is, that the sewers are able to discharge the

entire rainfall without bursting. The kind of fall though, which tests sewers to the utmost, is one distributed over *several* hours,—when it begins to rain at the rate of (say) ½ an inch an hour, continues at this rate (say) for an hour or two, then increases to (say) 1 inch per hour, continues again at this rate for an hour or two more, then increases to 1½ inch per hour for another hour, then to 2 inches and 2½ inches, and ultimately to as much as 3 inches ; then gradually decreases in the same way without there having been the slightest intermission from the beginning to the close of the storm. Any one who has been in the country for a few years will not think the above an exaggerated picture of the burst of a heavy monsoon.

I had hoped by an examination of the records in the Madras Observatory to have been enabled to place before Government some interesting facts with regard to the monsoons, but the very violence of these rain storms has hitherto prevented their being recorded with sufficient detail. Mr. Pogson, the Government Astronomer, has most kindly gone over the records of 20 years with me. But in nearly all the most interesting cases, after a few hours' rain, the anemometer has broken down and thus failed to record any results. There are fortunately two exceptions to this rule, and one of these, I am glad to add, is the greatest daily rainfall that has been known in Madras—the storm of October 1846, when about 23½ inches of rain fell in 24 consecutive hours. The details of this I give below.

The great storm of October 1846.

It appears to have commenced raining on the 18th October. Up to 6 A. M. on the 20th, however, only 3½ inches fell. It then progressed very steadily for about 20 hours, till the maximum rate of 2½ inches per hour was attained : after which it gradully decreased again till at the expiration of about another 12 hours when the monsoon was over. In this storm, Madras received, in 24 hours, *i. e.*, from 10 A. M. on the 20th to 10 A. M. on the 21st, about as much rain as falls in London during the whole year.

1846				Inches.
Oct. 20th	6 to 7	A. M.	.....	0·048
	7 to 8	„	.....	0·187
	8 to 9	„	.....	0·250
	9 to 10	„	.....	0·175
	10 to 11	„	.....	0·175
	11 to 12	„	.....	0·250
Total from 6 to 12 A. M.				1·085
	0 to 1	P. M.	.....	0·250
	1 to 2	„	.....	0·502
	2 to 3	„	.....	0·501
	3 to 4	„	.....	0·562
	4 to 5	„	.....	0·425
	5 to 6	„	.....	0·425
	6 to 7	„	.....	0·875
	7 to 8	„	.....	1·000
	8 to 9	„	.....	0·475
	9 to 10	„	.....	0·775
	10 to 11	„	.....	1·425
	11 to 12	„	.....	1·700
Total from 0 to 12 P. M.				8·915

				Inches.
Oct. 21st	0 to 1	A. M.	.....	2·000
	1 to 2	„	.....	2·525
	2 to 3	„	.....	1·925
	3 to 6	„	.....	4·800
	6 to 7	„	.....	0·750
	7 to 8	„	.....	1·080
	8 to 9	„	.....	0·250
	9 to 10	„	.....	0·750
	10 to 2-30	P. M.	.....	0·250
Total from 0 A. M. to close of storm				14·330

	Inches.
Heaviest fall in 1 hour (from 1 to 2 A. M. on 21st)	2·525
Heaviest fall in 6 hours (from 0 to 6 A. M. on 21st)	11·250
Heaviest fall in 12 hours (from 6 P. M. on 20th to 6 A. M. on 21st)	17·500
Heaviest fall in 24 hours (from 10 A. M. on 20th to 10 A. M. on 21st)	23·420

The storm of October 1857.

This certainly was a very extraordinary fall of rain, but the great monsoon of 1857 does not contrast unfavourably with it. Unfortunately we have no hourly record of it. We know, however, that 5·83 inches fell on the 24th October before sunrise, and 12·21 before sunset—thus making a total of upwards of 18 inches in about 18 hours.

The storm of May 1851.

In 1851, the south-west monsoon came down with a tremendous burst—11·45 inches fell in 5 hours. Thus—$2\frac{3}{4}$ inches in the 1st hour—2 inches in the next hour—nearly $3\frac{3}{4}$ inches in the next—$1\frac{3}{4}$ inch in the next—and $1\frac{1}{4}$ in the last. No underground sewers could stand against such a body of water as would flow into them at one of these outbursts of the monsoon. And these extraordinary falls seem to occur at intervals of about 8 or 10 years. I am given to understand that the main sewer of Calcutta is as much as 30 feet wide. While Madras remains as poor as she is, it will be folly to attempt the construction of sewers on such a scale.

Rain water must be removed by open channels.

It will naturally be asked, "If the sewers are not to carry away the rain water, how is it to be got rid of?" The answer is—"by open channels." I propose, however, at first, to make use of the existing large drains as the outlets for storms. This will, no doubt, cause surprise to many, considering how much the present drains have been abused. It is well known, in drainage engineering, that when the quantity of water is great, the form of the sewer is of little consequence. Whether it has a rectangular section or an oval section, the velocity is still sufficient for all possible purposes. Now, the section of the Madras drains is certainly very far from faultless. Nevertheless for storm waters they will answer admirably. When Madras can better afford it, it will be time to reconstruct these channels, but having them now at hand, I am decidedly of opinion that they should be used. The drains which I propose to keep are not, of course, the open *street* drains in all parts of Madras, but the few large underground and open channels which discharge immediately into the sea, the Cooum, or the Canal. All the street drains should be taken up, for the bricks of which they are constructed are of the worst possible kind and so saturated with liquid filth, that every effort to cleanse the town without the removal of these drains will be ineffectual. At present, all that would be necessary would be to re-place these drains with broken granite, down which the rain water would flow until it ultimately entered, as it now does, one of the large outlet drains. The Municipal Commissioners, who spend yearly about 20,000 Rupees in new drains, would have that sum available for this work, inasmuch as no new drains would be required in the town if this project were carried out. Ultimately it might become necessary to have open channels of stone set in mortar, similar to those in use in England.

On this question of the separation of rain-water from

sewage, I understand that it will be urged by the advocates of universal dry conservancy against me—"So, after all, your sewers will not get rid of the rain water." But these gentlemen forget that this argument tells, if possible, much more against them than against me. For, at all events, I do propose to dispose of all liquid refuse *except* storm waters, whereas the advocates of universal dry conservancy propose to get rid of 100th part only of the liquid refuse, and moreover of none of the storm water. If, therefore, it is necessary for the advocates of sewers, so also must it be necessary for the advocates of universal dry conservancy, to dispose of storm waters. It is no use to find fault with a sewer system from which storm waters are excluded, unless some mode of removing these storm waters, better than that suggested by me, is put forth by the objectors. All that I maintain is, that it will be unadvisable to adopt the European system of sewage in its entirety in Madras, simply because, if rain water is to run in the same channel with sewage, the discharging capacity of the channel in Madras must be *four* times what it is in London for the same area to be drained—that sewers laid down on this principle will be perfectly useless for eleven months in the year—and that the cost of them will ruin the Municipality.

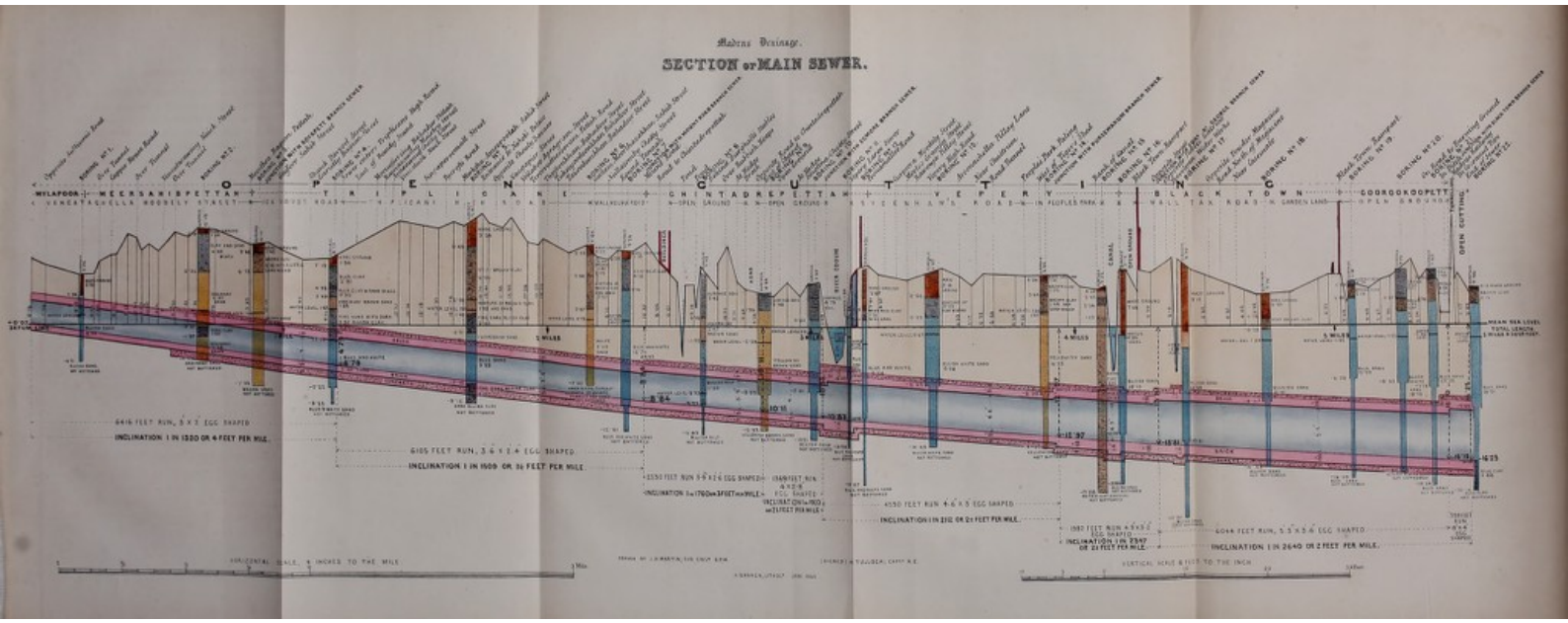
The general system of sewers proposed to be laid down will best be understood by reference to the accompanying map of Madras.

Main Sewer.

The Main Sewer will start from the village of Koshoopett near St. Thomè at mean sea level (datum line), and, after receiving all the sewage from that neighbourhood, will pass on through Meersahibpett. On entering Ice House Road, it will be joined by the Royapett Branch Sewer, and will then run eastwards until it arrives at the south end of the high road through Triplicane, when it will turn to the north and run through the heart of this populous district. On leaving Tri-

Madras Drainage.

SECTION OF MAIN SEWER.



plicane, it will enter the neighbourhood of Chintadrapett, and run beneath the open ground lying at the back of Messrs. Burghall's stables and on up to the road along the bank of the Cooum. It will then turn to the north, pass under the river, and continue its course along Sydenham's Road, which lies to the west of the People's Park. On leaving this road, it will cross the north-west part of the Park, and, running across the Canal to the south of Elephant Gate Bridge, will join Wall Tax Road, along which it will continue its course for about half a mile. On leaving this road it will enter the private garden lands lying to the north-west of Black Town, and, passing under the north Rampart, will run in a straight course, beneath the open plain, near the Government Distillery. It will subsequently cross the Madras Railway, and finally terminate at a point a few yards to the north of it.

Black Town Branch Sewer.

The Black Town Branch Sewer, which will drain nearly the whole of the neighbourhood between Salay Street and the sea, will run in the valley along Popham's Broadway, and, issuing out of Monegar Choultry Gate, will turn to the west and join the Main Sewer before it passes under the Railway.

Royapooram Branch Sewer.

The Royapooram Branch Sewer, which will drain all that portion of this district to the east of the ridge between the Canal and the sea, and also the north-east part of Black Town, will run parallel to the Coast and at about a quarter of a mile from it. As it enters Black Town, it will turn to the west, and, skirting the north of this neighbourhood, will join the Black Town Branch Sewer near Monegar Choultry Gate.

Coorookoopett Branch Sewer.

The small portion of the inhabited part of Madras which lies to the north of the Railway, and which does not drain into the Royapooram Branch Sewer, will be drained by the Coorookoopett Branch, which will run direct to the cesspool from this village.

Fort Saint George Branch Sewer.

The Fort St. George Branch will drain the Fort and the southern half of that portion of Black Town lying to the west of Salay Street. It will start from near St. Mary's Church, pass under the ramparts and ditches of the Fort, and take a westerly course until it reaches Wall Tax Road, when it will turn to the north and join the Main Sewer near Elephant Gate Bridge.

Pursewakum Branch Sewer.

The Pursewakum Branch will run in the valley of this neighbourhood, and after draining the whole of it will join the Main Sewer in the People's Park.

Egmore Branch Sewer.

The Egmore Branch, which will drain the whole of Poodoopett, will start from a point on the west bank of the Cooum near Lord Harris' Bridge, and will run along the bank of the river until it enters Poonamallee Road, along which it will continue its course up to its junction with the Main Sewer at the south-west angle of the People's Park.

Ellemboor BranchSewer

The Elemboor Branch will start from the village of Elemboor and keep a straight course up to its junction with the Egmore Branch, on the bank of the Cooum.

Mount Road BranchSewer

The Mount Road Branch is a small sewer which will run down the Mount Road from a point near the southern gate of Messrs. Waller and Co.'s stables to another point near the Round Tannah. It will be required for the drainage of the neighbourhood about the Madras Club.

Royapett BranchSewer

The Royapett Branch will start from a point in the heart of this village and run down Royapett High Road up to its junction with Ice House Road, where it will turn to the east and join the Main Sewer in Meersahibpett.

Saint Thomè Branch Sewers.

The peculiar configuration of St. Thomè renders two sewers necessary for its drainage. One of these will run to the north of the village, and the other to the west of it.

All the sewers proposed to be laid down in this Project are to be egg-shaped,—the diameter of the upper arch being double that of the invert. As it is now generally acknowledged by the Engineering profession that this is the best form for sewers where the quantity of sewage is constantly varying, it is unnecessary for me to dwell on the advantages of adopting it for the Madras sewers. All sewers to be egg-shaped.

The formula by which the dimensions and slopes of the sewers have been calculated is the one used by Mr. Beardmore in his work, "Manual of Hydrology;" Hydraulic formula.

$$v = 55 \sqrt{2hf},$$

in which v is the velocity of the stream in feet per minute—h the hydraulic mean depth in feet — and f the fall in feet per mile.

A single example will best explain how the dimensions of the sewers for the Main Line have been decided on. Dimensions of sewers, how calculated.

It has been assumed that the quantity of water used per head of the population may ultimately be as high as twenty gallons per diem. Excepting the western portion of the neighbourhood lying to the north of the Railway, the population of which is about 54,000, the whole of Madras will be drained through the Main Sewer. If the population of Madras be taken at 428,000, the total quantity of water flowing into the cesspool in 24 hours through the Main Sewer will be (428,000 — 54,000) × 20 gallons = 7,480,000 gallons or 1,196,800 cubic feet. Assume that half this quantity, or 598,400 cubic feet, will run off in 8 hours, the period of maximum daily flow, then the quantity to be discharged every minute by the Main Sewer will be

$$\frac{598{,}400 \text{ cubic feet}}{8 \text{ hours} \times 60 \text{ minutes}} = (\text{say})\ 1{,}247 \text{ cubic feet.}$$

Now, a sewer 6 feet by 4 feet, laid at a slope of 2 feet per mile, will discharge upwards of 1,650 cubic feet per second, assum-

ing the co-efficient of friction to be ·75. The velocity of the stream would be about 18 inches per second. Allowing a large margin for prospective population, I think if the Main Sewer at its junction with the cesspool is 6 feet by 4 feet and laid at an inclination of 2 feet per mile, it will be quite large enough. I very much doubt if the Main Sewer will for many years be more than one-third full. But it is safer to make the sewers too large than too small.

The general principles of drainage on which this Project is prepared.

As it is not intended that the sewers proposed to be laid down according to this Project shall remove rain water, it is necessary that the principles on which the general system of drainage have been designed should be explained. In order to utilize to the utmost the natural slopes of the ground for the street drains, I have run the Main and Branch Sewers, as a general rule, along the valley lines of each neighbourhood. To ascertain, however, *at what depth* they should be placed below ground, I commenced laying down the street drains from the highest points in each district, and working down to the Main and Branch Sewers. The slopes given to the street drains, which will be earthenware pipes of 6 and 9 inches in diameter, are such as to admit of the sewage flowing through them at the velocity of at least 3 feet per second. The 6-inch pipes at the highest points in each district will be laid at an inclination of from 1 in 150 to 1 in 100, and, in those streets which are situated nearer the valleys, the slopes of the drains will be much greater than this. The slopes of the 9-inch pipes range from 1 in 250 to 1 in 170. In fact, the levels at which the sewers are put below ground are such as to admit of the pipe-drains in all the streets being laid at such inclinations as will generally enable them to keep themselves clear of deposit.

Drainage of Black Town.

On the accompanying plan of Black Town, the complete system of sewers and pipes for this district is shown. The


Peoples Park
Salt Depôt
Basen
Basen Bridge
Elephant Gate Bridge
Hospital Bridge
MAIN SEWER
FORT ST GEORGE BRANCH SEWER
MAIN SEWER
General Hospital
Medical College
Marine Hall
FORT ST GEORGE BRANCH SEWER
Mint
Water Works
BLACK TOWN BRANCH SEWER
BLACK TOWN BRANCH
Madras Drainage.
PLAN OF BLACK TOWN
SHOWING THE SYSTEM OF STREET DRAINS
PROPOSED TO BE LAID DOWN
FIGURES ENCLOSED IN A CIRCLE THUS -6 OR +6 DENOTE THE LEVELS AT WHICH THE INVERTS OF THE PIPES ARE TO BE LAID WITH REFERENCE TO DATUM LINE OR MEAN SEA LEVEL.
ALL OTHER FIGURES DENOTE THE LEVELS OF THE STREETS WITH REFERENCE TO DATUM LINE.
SEWER.
9 INCH EARTHENWARE PIPES.
6 INCH ——— 0" ——— 0"
Light House
Grand Jail
ROYAPOORAM BRANCH SEWER
BLACK TOWN BRANCH SEWER
Scale 6 Inches to the Mile
4 Furlongs
A. BARKER, LITHOG. JAN: 1855
(SIGNED) H. TULLOCH, CAPTT. R.E.

general principles of drainage which I have adopted will be better understood by an examination of this plan than by any written explanation on my part.

I have given the greatest consideration to the question of slope. Had the strata on which Madras stands been favourable to the construction of sewers at a great depth, I should have laid them at a much greater slope than that on which they are placed at present, but these strata consist almost everywhere of sand or clay, and water is found in all parts at about the level of the datum line. The building of the sewers, therefore, if they were put very deep below the surface, would be difficult, and attended with considerable expense. I have preferred to adopt a medium slope, and propose to turn the abundance of water to use in flushing the sewers.

Details of Main Sewer.

The Main Sewer at its head will be 3 feet by 2 feet, and laid at an inclination of 4 feet per mile, and at its termination it will be 6 feet by 4 feet with an inclination of 2 feet per mile. It will start at about the level of the datum line and will terminate at the level of 16·25 feet below the datum line. Where each Branch Sewer joins the Main, the dimensions of the latter will be increased, and as the Main Sewer becomes larger the slope will be gradually decreased.

Dimensions and slopes of Branch Sewers.

All the Branch Sewers, without exception, are to be 3 feet by 2 feet, and to be laid at an inclination of 4 feet per mile. They are considerably larger than they need be, so far as the quantity of sewage which they will have to convey away is concerned, but it would be difficult to cleanse a sewer of smaller dimensions thoroughly. I had thought at one time of using large earthenware pipe-drains for the branch sewers, but the expense of these would be as great as that of the sewers now proposed.

One uniform

The entire system of sewers is designed to secure one uni-

velocity of flow throughout the sewers.

form velocity (about 18 inches per second) for the sewage throughout its flow from the beginning to the end of each sewer.

Junctions.

All junctions between the sewers will be effected by Bell-mouth Junctions.

Outfall Sewer

As fast as the sewage arrives at the end of the Main Sewer, it will be pumped up by means of steam pumps to a height of 10 feet above the datum line, and it will immediately enter the Outfall Sewer, which will carry it to the sea. The position of this Outfall Sewer is shown in the map of Madras which accompanies this report. Its dimensions are the same as those of the Main Sewer at its junction with the cesspool, but while the inclination of the latter is 2 feet per mile, that of the Outfall Sewer is 3 feet per mile. This extra fall has been given with the view to secure a greater velocity for the flow of the sewage, as there will not be those facilities for flushing the Outfall Sewer which exist for the other sewers.

A great portion of the Outfall Sewer will run above the surface of the ground, but the line which has been adopted for it is very favourable, and no impediments to traffic will in any way be caused by this work.

Outfall.

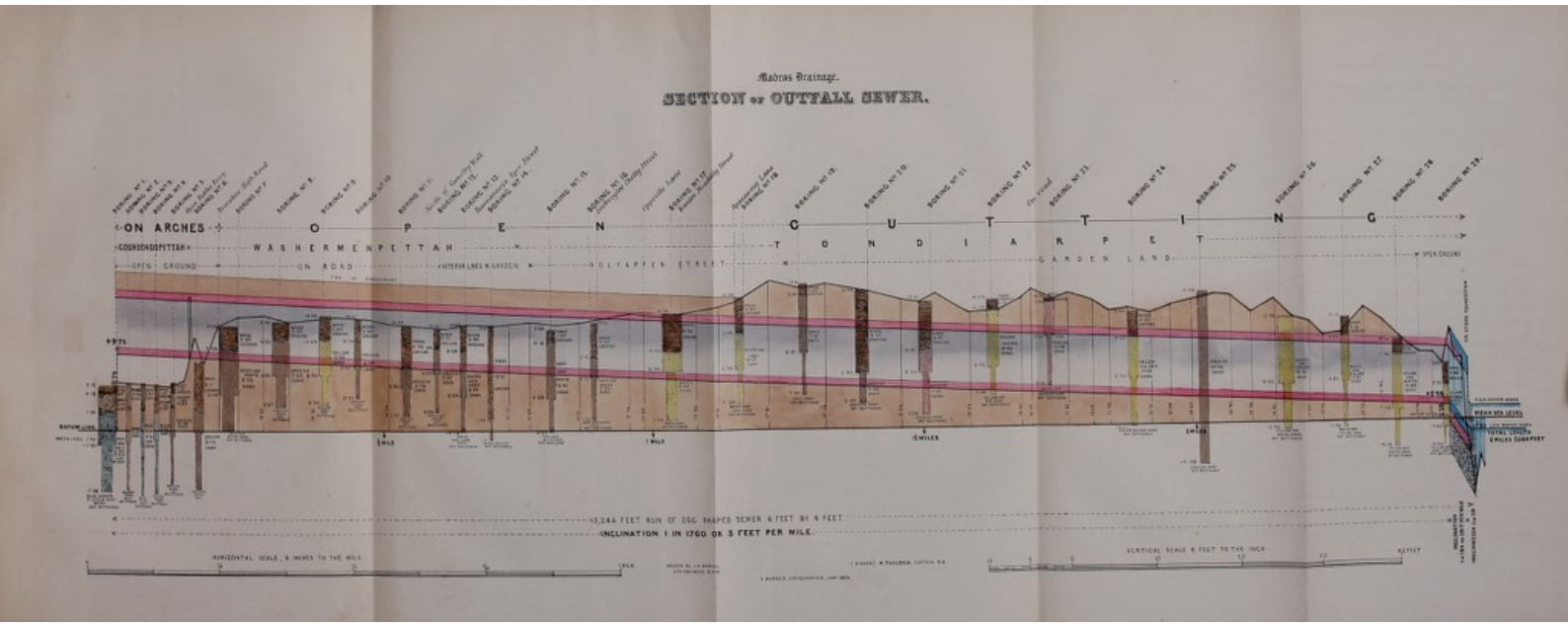
The Outfall into the sea has been designed with great care. It will be built of solid ashlar masonry, standing on a groyne of granite boulders run out 200 feet into the sea. The invert of the sewer will be on a level with low water-mark. I think the Outfall will be found strong enough to resist the action of the surf.

Arrangements for ventilating the sewers.

Every sewer will be thoroughly ventilated through charcoal disinfectors. The ventilators will be placed at about 100 yards apart, and will be so arranged that dust or gravel falling through them from the roads will be intercepted and prevented from

Madras Drainage.

SECTION of OUTFALL SEWER.



entering the sewers. The dirt can be removed at stated times without interfering with the action of the ventilator.

Man-holes and side-entrances.

In connection with every ventilator there will be either a man-hole or side entrance leading into the sewer, so that, when necessary, men may easily enter the sewers to clean or inspect them.

Flushing arrangements.

The St. Thomè and Outfall Sewers being above the level at which water is found, arrangements cannot be made for collecting water below ground for flushing them, but for all the other sewers there will be a flushing apparatus in connection with every ventilator and man-hole or side entrance, as the case may be. The flushing arrangements will, therefore, occur at intervals of about 100 yards apart, and it is expected that each apparatus will cleanse the sewer thoroughly up to that point in it where the next apparatus occurs.

The accompanying plan represents a flushing reservoir in connection with a man-hole and ventilator. The foul air from the sewer will travel up the man-hole shaft—pass through the charcoal in the box *a*, the bottom and top of which will be made of iron wire netting—and will escape, first through the opening *b*, and then through the ventilator *g*, to the open air. Any gravel or dust falling through the ventilator will be intercepted in the chamber *c*, and when it is necessary to remove the rubbish, the trap door *d* will be opened, the box *a* pushed into the recess *e*, and the chamber *c* will be cleansed through the door *f*, on the opening of which the rubbish will fall out and be received in a basket held at the mouth of the entrance. When the rubbish has been removed, the door *f* will be closed, and the box *a* will be pulled out of the recess and replaced in its original position over the man-hole shaft. Thus, all the foul air that escapes from the sewer will be made to pass through the charcoal which, it is expected, will, in a great measure, disinfect it.

At the bottom of the man-hole shaft there will be a masonry reservoir, (capable of holding about 350 gallons of water), which will be fed from a filtering well. The reservoir will be connected with the sewer by an iron pipe (6 inches in diameter) furnished at one end with a stop valve and at the other with a sluice gate. The water from the filtering well will pass into the reservoir through a small pipe, and when the reservoir has sufficient water collected in it, the pipe will be closed by a self-acting ball-valve.

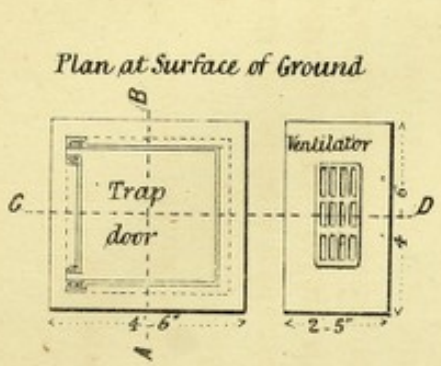
In order to flush the sewer, the man employed on the work will first open the trap door at the surface of the ground—he will then descend the ladder, and, pushing the box of charcoal into its recess *e*, pass down to the bottom of the man-hole shaft. A few turns of the handle fixed to the stop valve will open the mouth of the flushing pipe, when the water from the reservoir will rush through it, open the sluice gate *k* by the force of its pressure, and pass into the sewer with considerable velocity. After all the water has escaped, the sluice gate will fall down by its own weight, and the stop valve will be closed by the man, who may then leave the reservoir to fill again, and pass up the ladder to the open air. As soon as the reservoir is emptied, the water from the filtering well will begin to flow into it, and in the course of a few hours the whole apparatus will be again ready for use.

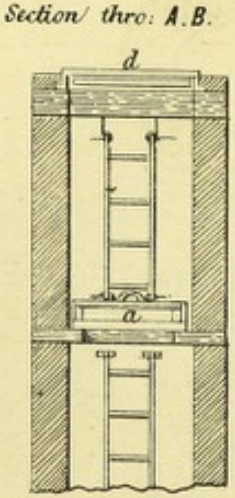
It is expected that a pressure of 2 feet of water in the reservoir will give a sufficient scouring velocity to the water. If, however, this amount of pressure should, in practice, be found insufficient, the reservoir can be filled to the depth of 3 feet by altering the position of the ball-valve.

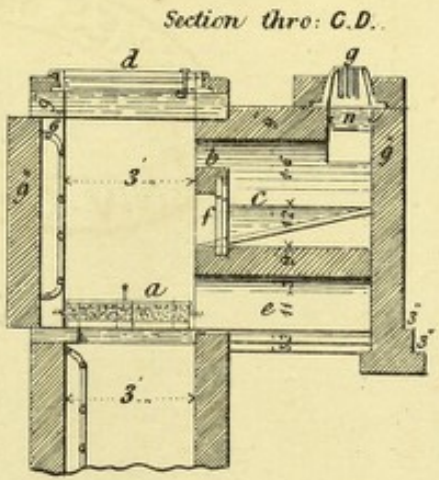
The Outfall Sewer and the St. Thomè Branch Sewers must be flushed by forming temporary dams across them and removing the dams suddenly. This is practised in England and found to answer.

Madras Drainage.

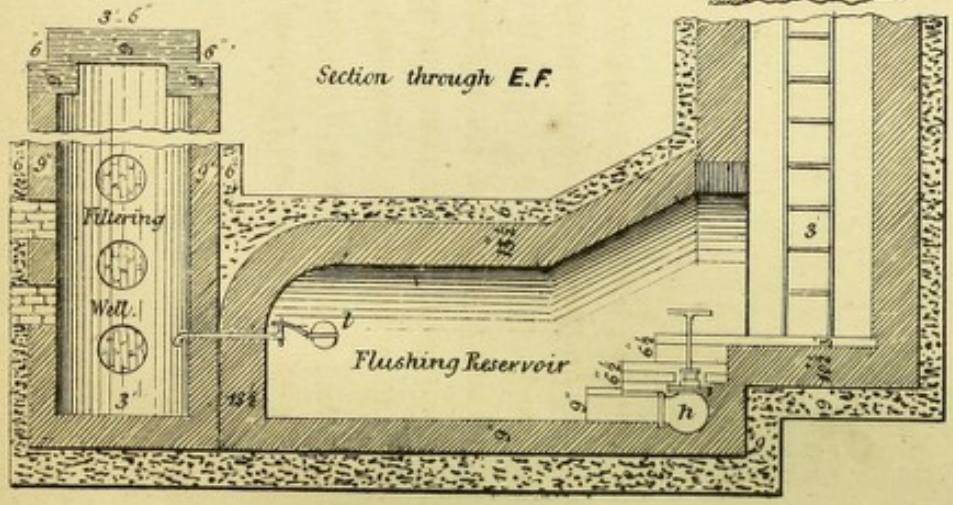
PLAN AND SECTION OF
MANHOLE, VENTILATOR AND FLUSHING RESERVOIR.

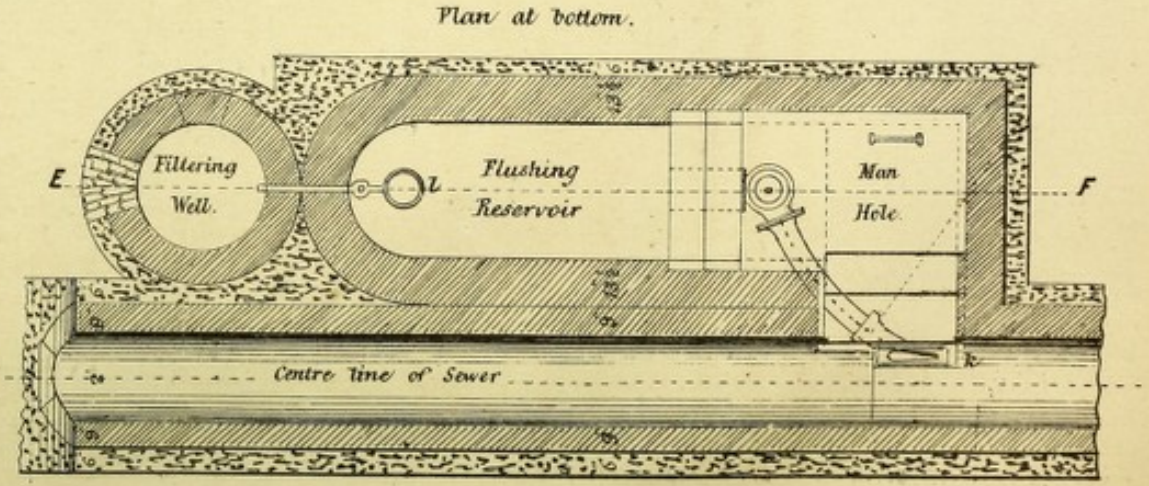






a. Box filled with Charcoal.
b. Opening in Wall.
c. Chamber to catch road grit.
d. Trap-door.
e. Recess for Charcoal box.
f. Door to Chamber.
g. Ventilator.
h. Stop Valve.
k. Sluice Gate.
l. Ball Valve.





A. BARREN. LITHOGR. MADRAS.

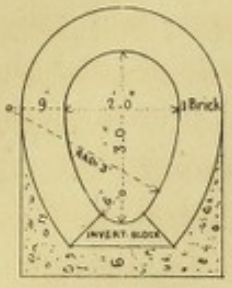
SCALE. ⅜ OF AN INCH TO THE FOOT.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 Feet.

DESIGNED BY H. TULLOCH
CAPTN R.E.

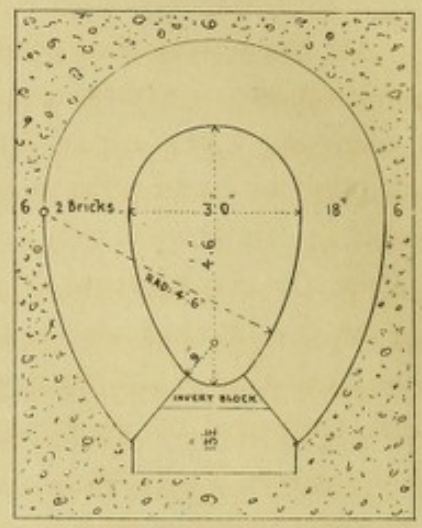
Madras Drainage.

CROSS SECTIONS OF SEWERS.

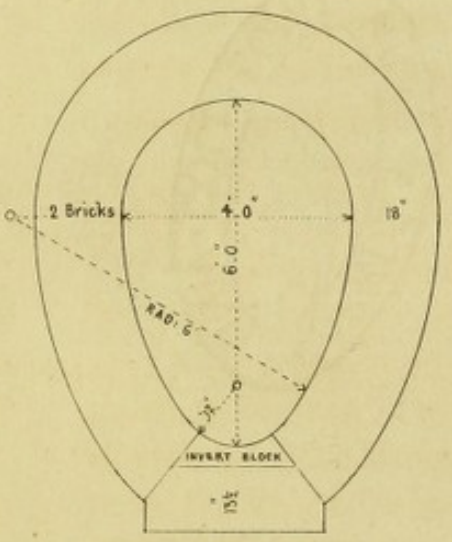
CROSS SECTIONS OF MAIN SEWER.



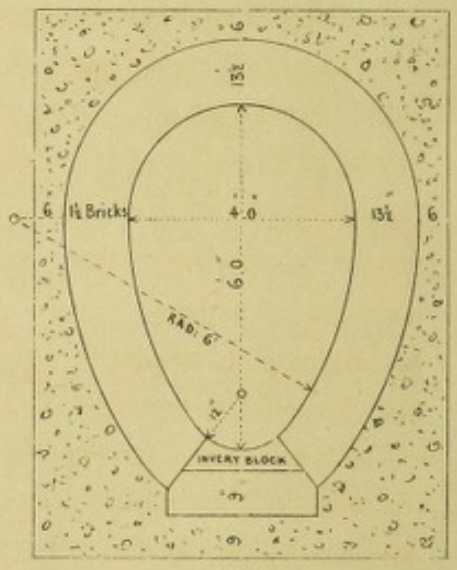
AT BEGINNING



UNDER THE COOUM.

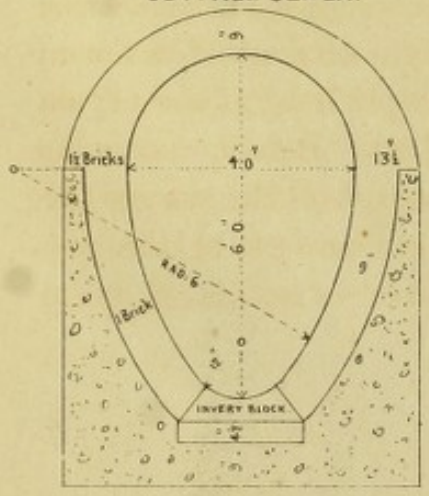


UNDER THE MADRAS RAILWAY.

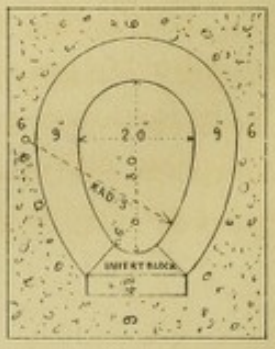


AT END.

GENERAL CROSS SECTION OF OUTFALL SEWER.



GENERAL CROSS SECTION OF BRANCH SEWERS.



SCALE - 4 FEET TO AN INCH

LITHOGRAPHED BY A. BARREN. JAN: 1865.

5 4 3 2 1 0 5 Feet.

[SIGNED] H. TULLOCH. CAPTN R.E.

Materials to be used in the works.

All the sewers and other works will be constructed with machine-made steam pressed bricks laid in the best hydraulic cement. The inner surface of the sewers and other works will be lined with asphalte half an inch thick, and the inverts of the sewers will be formed with earthenware blocks of English manufacture. Round those sewers which run beneath the level of water, there will be a casing of concrete. A general idea of the form of the sewers and the manner in which they will be constructed may be obtained from the accompanying diagram.

Pumping power required.

Assuming that 20 gallons of water will be used, per diem, per head of the population, the total quantity of sewage to be raised by the steam pumps daily would be :—

Population of Madras. Gallons. lbs.

$$428{,}000 \times 20 \times 10 = 85{,}600{,}000 \text{ lbs.}$$

And if half this quantity be supposed to enter the cesspool during the 8 hours of maximum flow, the power of the engines should be sufficient to raise 42,800,000lbs. in 8 hours. The average lift from the cesspool into the outfall sewer would be $26\frac{1}{4}$ feet. The power of the pumps, therefore, should be :—

lbs. feet.

$$\frac{42{,}800{,}000 \times 26\frac{1}{4}}{33{,}000\text{lbs} \times 8 \text{ hours} \times 60 \text{ minutes.}} = \text{say } 70 \text{ horses.}$$

I consider that two engines, each of 36 horse power, would be ample for all purposes. I would not recommend the erection of a third engine as a reserve, for I very much doubt if, for many years, the quantity of water used daily per head of the population, will even approximate to 20 gallons. Indeed, one engine of 36 horse power would, in my opinion, lift all the sewage that might flow into the cesspool during any hour of the day. The second engine, therefore, would be as a reserve. If, at any

future period, it were found that these two engines were not sufficient for the work required of them, a third could easily be procured, but it would be very unadvisable to go to the expense of providing more engine power at first than could be utilized afterwards.

Cesspool. By the cesspool, to which I have alluded so often, it must not be supposed that a large reservoir for ponding up the sewage for many hours is intended. This system, which is practised in England, and of which the most notable examples are to be found in the Grand London Drainage Works is obviously not suited to a country like India where decomposition sets in so rapidly. The cesspool for the Madras Drainage Works, will be a small well of, perhaps, 8 or 10 feet in diameter, into which the sewage will be led for conveniences of pumping. During those hours of the day when there is little or no sewage to be raised the engines will be stopped and the sewage will be allowed to accumulate in the Main Sewer, which, in fact, will be the ponding reservoir, and take the place of those enormous cisterns which are constructed in Europe.

Engines and Boilers. As so many improvements are yearly made in England in pumping engines, of which the Indian Engineer is not so much as aware, I have thought that it would be useless for me to attempt the designs for the engines for the Madras Drainage Works. Much better designs could be obtained by the Government from some one of the numerous Engineers in England, who devote their entire attention to this class of work. A few remarks as to the requirements of the engines for Madras will not be out of place here. First, the boilers must be constructed on the most improved principles, and with the view to the smallest consumption of fuel in proportion to the work performed. Where, as in Madras, coal is sometimes not to be had at less than 50 shillings per ton, the necessity for the careful construction of the boilers, with the object of saving fuel, cannot be exagge-

rated. 2ndly. The boilers must be made for the combustion of either coal or wood. 3rdly. In connection with the pumps, arrangements must be made for separating, if necessary, the liquid from the solid portion of the sewage : and a filth-hoist for the purpose of raising the latter must be erected to be worked by the engines. I would leave it to the Engineer in England to decide what style of engine should be adopted—whether high or low pressure, whether condensing or non-condensing, whether single acting or double acting, &c.

Pumping Station.

On receipt of the plans of the engines, the buildings at the Pumping Station can be designed. With this report is forwarded a plan and sections of the ground where the sewage is to be raised, and such information is given on the plan as will enable the Engineer in England to understand the special requirements of the case.

Street Drainage.

The street drainage will be effected by means of 9-inch and 6-inch glazed earthenware pipes of English manufacture. Only in one instance will a pipe of larger dimensions be laid down. I propose to use pipes of these two sizes as the most convenient for the objects in view. Every street will be drained by a 6-inch pipe leading to a 9-inch sub-main, which will run directly to the main or branch sewers. The 6-inch street pipes will usually begin at 3 feet below the surface of the ground, and will slope down uniformly to meet the 9-inch sub-mains. The least slope for the 6-inch pipes will be at the top of the ridges in each District (about 1 in 150), and the greatest slope in those streets which are nearest the main and branch sewers (about 1 in 50). In laying down the street drains, it will be necessary to provide means of access to them at intervals of about three hundred feet apart, so that they may be easily cleansed when obstructed. In connection with these entrances leading to the drains, ventilators and small flushing reservoirs might be formed, similar to those adopted for the sewers. Where the pipes were above the

level of the water, some other means of flushing would have to be arranged. A water-cart, with a long hose, would, perhaps, be the simplest plan.

I would strongly urge that the pipes used for the Madras drainage be of the kind known as "saddle and chair" pipes. If they get broken, they can easily be removed and others can be substituted without shifting more pipes from their position in the line than the number to be replaced.

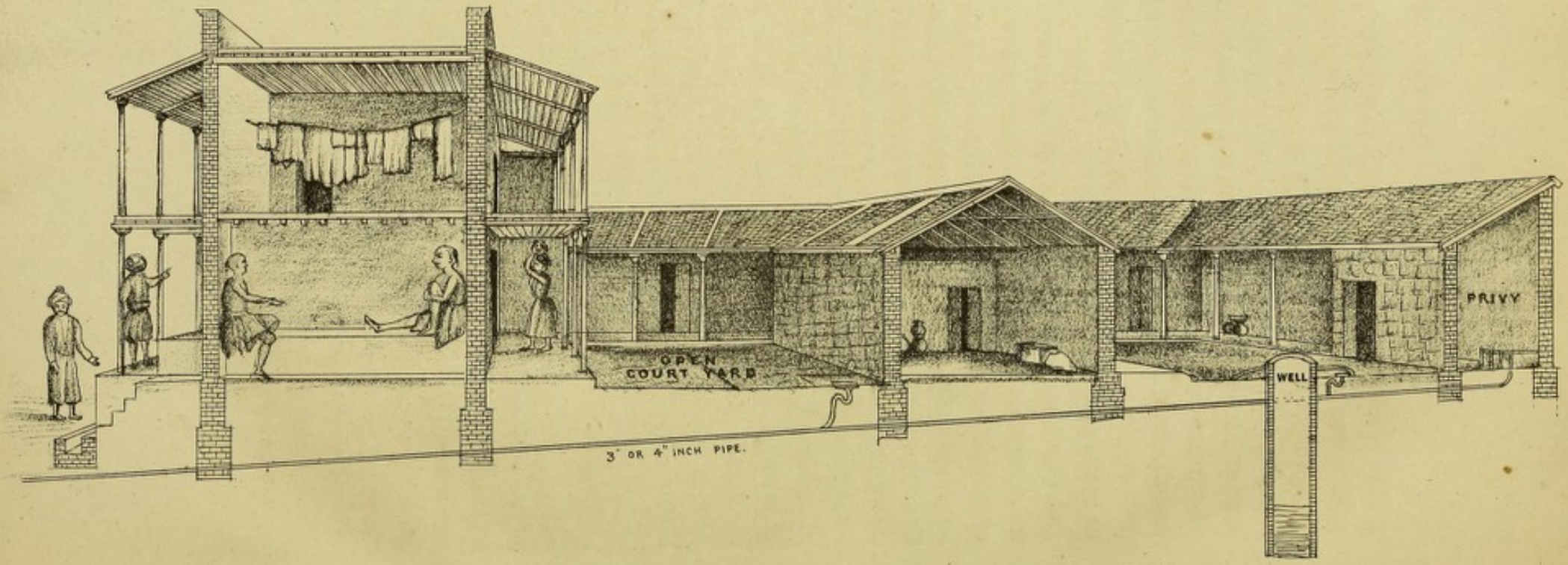
House Drainage.

The house-drainage will be effected by three and four-inch earthenware pipes laid at as great an inclination in each instance as the internal arrangements of the walls and rooms of the dwelling will admit of. The pipes will start from the back yard of the house and will issue into the street from under the front door of the dwelling. The admirable system known as "back drainage" in England cannot be adopted in Madras. The destruction of property would be so great as to put it entirely out of the question. In London, where there is generally an open yard at the back of every house, there is no difficulty in draining the houses to the rear—in fact, it is cheaper to do so, but in Madras the back-yard to the house is surrounded by small buildings, the destruction of which would be necessary before a pipe could be laid. Every house, moreover, invariably slopes, and some very considerably, *from* the back-yard *towards* the street. To attempt "back drainage" will be to drain the houses against the natural slope of the ground. Many objections may be found and urged against carrying the pipe through the entire length of each man's dwelling and taking it into the street drain from under his front door, but long attention to this subject, and a careful inspection of numerous dwellings all over the town, have convinced me that this is the only method at our disposal. It is not possible to make use of the present house drains, which are usually channels of about 4 inches square, and run beneath the wall

Madras Drainage.

PERSPECTIVE SECTION OF A FIRST CLASS NATIVE HOUSE IN MADRAS.

showing the System of drainage proposed.



A. BARREN, LITHOGR MADRAS.

DRAWN BY H. TULLOCH. CAPTAIN, R.E.

which separates two contiguous buildings, and is common to both. These drains having been built along with the houses, there is no means of getting at them except by pulling down the walls, which cannot be done without causing damage to the dwellings. In many of the streets, the slopes which have been given to these channels are very slight, and they constantly become choked up in consequence.

I considered at one time whether it would not be possible to dispense with new house drains altogether, and to use the present channels although they are so defective. But I found, if this were attempted, that the dimensions of the main and branch sewers would have to be enormously increased, and at least *six* times the amount of pumping power already recommended would have to be provided. I will try and make this clear.

The number of houses in Madras is 32,610. The area of each, together with the open yards attached, may, at a fair calculation, be taken at 1,000 square feet. The whole of the rain-water falling on this area is drained into the streets by the present house drains. If, therefore, these drains are to be used, the main sewer must be capable of discharging not only the sewage proper of all the houses, but also the rain which falls on an area of (32,610 houses × 1,000 square feet =) say 32,610,000 square feet. Now, I have already shown (page 88) that 24 inches of rain have been known to fall in 24 hours in Madras. But I will not take such an exceptional case for purposes of calculation. In page 86, it will be seen that between the years 1822 and 1857 there have been twelve instances in which upwards of 6 inches of rain have fallen in 24 hours. In other words, a fall of 6 inches in 24 hours occurs, on an average, about every third year. This, I think, therefore, every one will admit, is a fair datum for calculation. Now if the sewers could not discharge this quantity, we may be perfectly certain that they would be always liable to burst whenever a heavy fall of rain

occurred. A fall of 6 inches in 24 hours would render it necessary that the main sewer should be capable of discharging every minute $\left(\frac{32,610,000 \times \frac{1}{2}}{24 \times 60}\right)$ at least 11,200 cubic feet of water. To this must be added about 1,600 cubic feet of sewage, so that the total discharging capacity of the main would be, say in round numbers, 13,000 cubic feet per minute. A barrel sewer, 10 feet in diameter, laid at a slope of two feet per mile, would be required for this, but its cost would be at least *three* times as great as that of the main sewer proposed to be laid down by me. The cost of all the branch sewers would, in like manner, be greatly increased. If I take the cost of the Main Drainage according to this project at twenty lacs of rupees, the cost of the Main Drainage, if the sewers are constructed to discharge the rain which falls on the houses, would be fifty lacs of rupees, and while, in the former case, pumping engines of about 72 horse power would probably be sufficient for all purposes, in the latter case we should have to provide additional power to the extent of upwards of 400 horses. The cost of this, calculated at 1,500 Rupees per horse power, would be six lacs of rupees. This additional horse power, moreover, would not be required except for one day in every three years.

If the sewers could be arranged to admit of the construction of storm-overflow channels leading to the sea and to the other natural outfalls about Madras (such, for instance, as the River Cooum and the Canal), a great portion of the rain during heavy monsoons might be prevented from entering the sewers ; but much as I have thought over the question, I cannot see how this can be done. Madras is, for all drainage purposes, almost a dead flat, raised only from 3 to 6 feet above the sea, and it covers 27 square miles of country. A free outlet, under these circumstances, I have already (page 80) attempted to show, is impossible. The sewers must be laid at a considerable

depth below the level of the sea, the Cooum, and the Canal. If this is not done, all the street drains will be constantly becoming choked up for want of sufficient slope. If, therefore, the sewers are placed below the level of the natural outfalls in Madras, no storm-water can be passed off into these, unless the sewers are subjected to great pressure of water—an alternative which few would recommend.

All these considerations have led me to the conclusion that in Madras, where the conditions of rainfall are so different to those in England, it would be advisable to effect a perfect separation between rain-water and sewage. I would, therefore, leave the present house drains as the discharging channels for rain-water, and would lay down three and four-inch earthenware pipes in the manner already proposed in page 102 for the sewage. In every yard, or wherever water may be used within a native dwelling, there would be a small cistern fitted up with a sink. The earthenware pipe, which would run from the back to the front of the house, would, in most cases, pass directly under these sinks and be connected with them by syphon traps.

To illustrate my meaning, I will take the most ordinary case—a native dwelling with, say, three open yards, one behind the other, and with a well in the back, and another in the front, yard. The earthenware pipe would start from near the well in the back yard, run across the second yard to the well in the first yard, and thence pass through the dwelling and out under the front door. It would join the street drain in the middle of the street. Round each well it would be necessary to put up a brick dam two or three inches high—just sufficiently high to intercept the water, and sufficiently far from the parapet of the well to admit of the inmates of the dwelling bathing and cleaning their pots in the space between the parapet and the dam. A sink would be fixed in this open space

so that all the water that was used at the well would escape through the sink and pass at once into the earthenware pipe. In many cases the dam would not be required, for there is already a channel from each well, and the sink might at once be fixed in it. Care should be taken not to lay it at the lowest point in the open yard, as, in that case, the rain falling on the roofs of the houses and in the yard would enter the earthenware pipe.

The house drainage should be carried out under the immediate direction of the Municipal Commissioners. Every house-owner should be at liberty to lay down the drains in his house himself, subject to the approval of the work by the Commissioners, or, if he preferred it, the Commissioners should lay down the drains for him at their own cost, and increase the rate charged on the house by such a sum as in 30 years would amount to the value of the work done with interest thereon.

The removal of excreta.

I must not omit to explain in this place how I intend that the excreta should be disposed of. So far as the urine is concerned the matter will be very simple. The connection at present between the privy drain and the house drain will be stopped, and the former will be joined to the new earthenware pipe through which all the urine will escape to the sewers. For the removal of the ordure I would encourage, as much as possible, the system which obtains at present throughout the town,* but I would, at the same time, try to improve it. The abominable smells in all parts of Madras are not produced, as is generally supposed, by the excreta of the population, but by defective drainage. It is the *refuse water* in the houses and in the streets into which all manner of garbage is thrown to ferment and generate foul gases, that creates the dreadful nuisances so much complained of. What is chiefly required to prevent excreta producing a nuisance is a constant

* Vide page 16 of this Report.

inspection of the privies in the dwellings. Although the ordure is removed daily, yet the privies themselves are not kept clean. Very often there is a stoppage in the channel which carries away the urine, or the ordure is dropped on the bare floor from which it is impossible to remove it altogether. Now, if the Municipal Commissioners would organize a system of inspection and insist on every householder keeping his privy in a wholesome state, we might soon get rid of the evil. Of course, the use of clay, ashes, &c., should be encouraged as much as possible. This would be nothing more than the dry system applied to dwellings, and would have this advantage, that each householder would be saddled with no more than the expense of removing the nuisance produced in his own house and by his own family. The cost of this plan to the Municipality would really be most trifling. For the first few months it might be necessary to examine each privy once in every two or three days, but after a few men had been punished for the filthy state of their privies, even this amount of inspection would not be called for. A weekly inspection would subsequently answer every purpose. Twenty-five Native Inspectors would suffice for the whole of Madras. In each District there should be one European or East Indian Superintendent, who should keep the Inspectors up to their work, and receive their daily reports. Both the Superintendent and the Inspectors should have no work but that of looking after the privies.

If each Superintendent received 30 Rupees, and each Inspector 7 Rupees monthly, the total yearly cost of (say) 8 Superintendents and twenty-five Inspectors would not amount to 5,000 Rupees. The only objection which may be urged against this scheme, is, perhaps, that the householders would object to the privacy of their dwellings being invaded for the inspection of their privies. But, considering that ultimately

the privies would not require to be inspected more than perhaps once a week or so, and that sweepers at present enter each house every day to clear away the ordure, the above objection would really be an absurd one.

The best system for the removal of excreta is the sewer system—provided that plenty of water can be employed to carry away the urine and ordure, and that a liberal use can be made of some deodorizing solution to prevent effluvia. There is nothing to equal the water-closet for cleanliness and wholesomeness. It acts perfectly if deodorizers are used as well as water. Both deodorizing and antiseptic solutions will, before long, be procurable at prices that will admit of their free use even by householders, but many years must elapse before every house in Madras is supplied with water. Until then, I am satisfied that it will be best to continue the present system.

The utilization of the sewage.

Having now explained the Project generally, it is necessary that I should return to a point in connection with it to which I have hitherto only alluded, in order that the description of the works should be as clear and uninterrupted as possible. In the chapter headed "Objections to Sewers" (from page 50 to 59), I have already attempted to prove that sewage is a valuable manure, and that those who are best qualified to speak on the subject are unanimous in the opinion that it should not be wasted but applied to agricultural purposes. It is unnecessary, therefore, that I should repeat the arguments in this place. The points to which I now wish to draw attention are the very favorable position of Madras for the utilization of its sewage, and the rare opportunity thus afforded to Government of making an experiment on a large scale on this very important question of the day.

The land on which it is proposed to use the sewage lies to the north-west of Madras. It is a portion of that exten-

Madras Drainage.

CHART

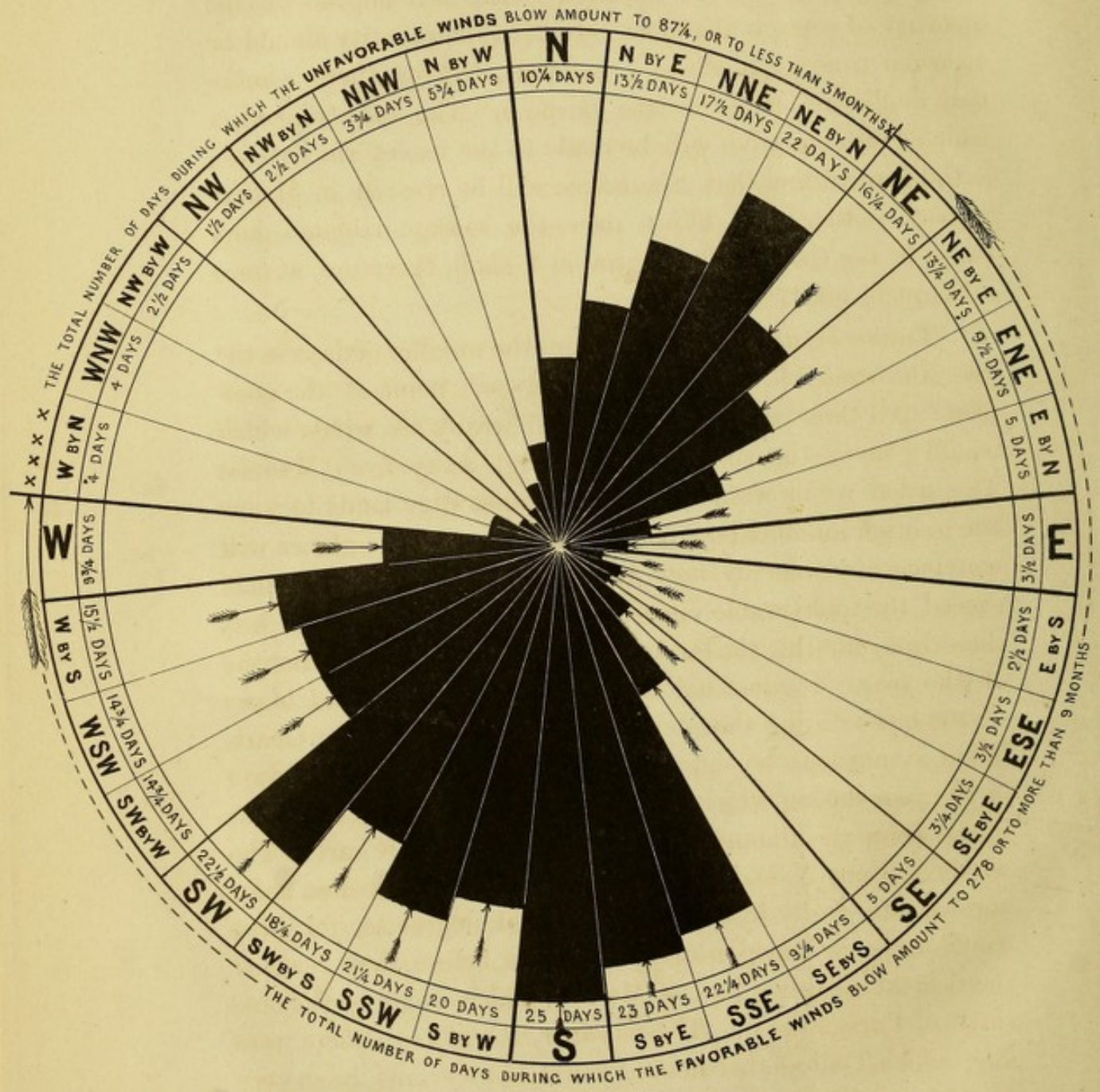
SHOWING THE NUMBER OF DAYS IN THE YEAR

THE **WIND** *BLOWS*

IN

MADRAS

FROM EACH POINT OF THE COMPASS.



The favorable Winds or these which would convey the smell of the Sewage away from Madras, are marked with arrows.

Note. The Results shewn above are averages of 5 Years observations.

A. BARREN LITHOG: JAN: 1865

DRAWN BY H. TULLOCH, CAPTAIN R.E.

sive low-lying tract stretching toward the north, along which the Canal runs. The average level of the land is from 2 to 6 feet above datum (mean sea level). It is not possible to say how much land will be required ; that will depend on the quantity of sewage available. But if this quantity should be even ten times as much as I have allowed for, there is more than sufficient land for the purpose. The only objection which I can conceive will be made to the use of the sewage, is the general one that a nuisance will be created in Madras whenever the wind blows over the sewage-irrigated land towards the town. This objection I shall, therefore, at once attempt to meet.

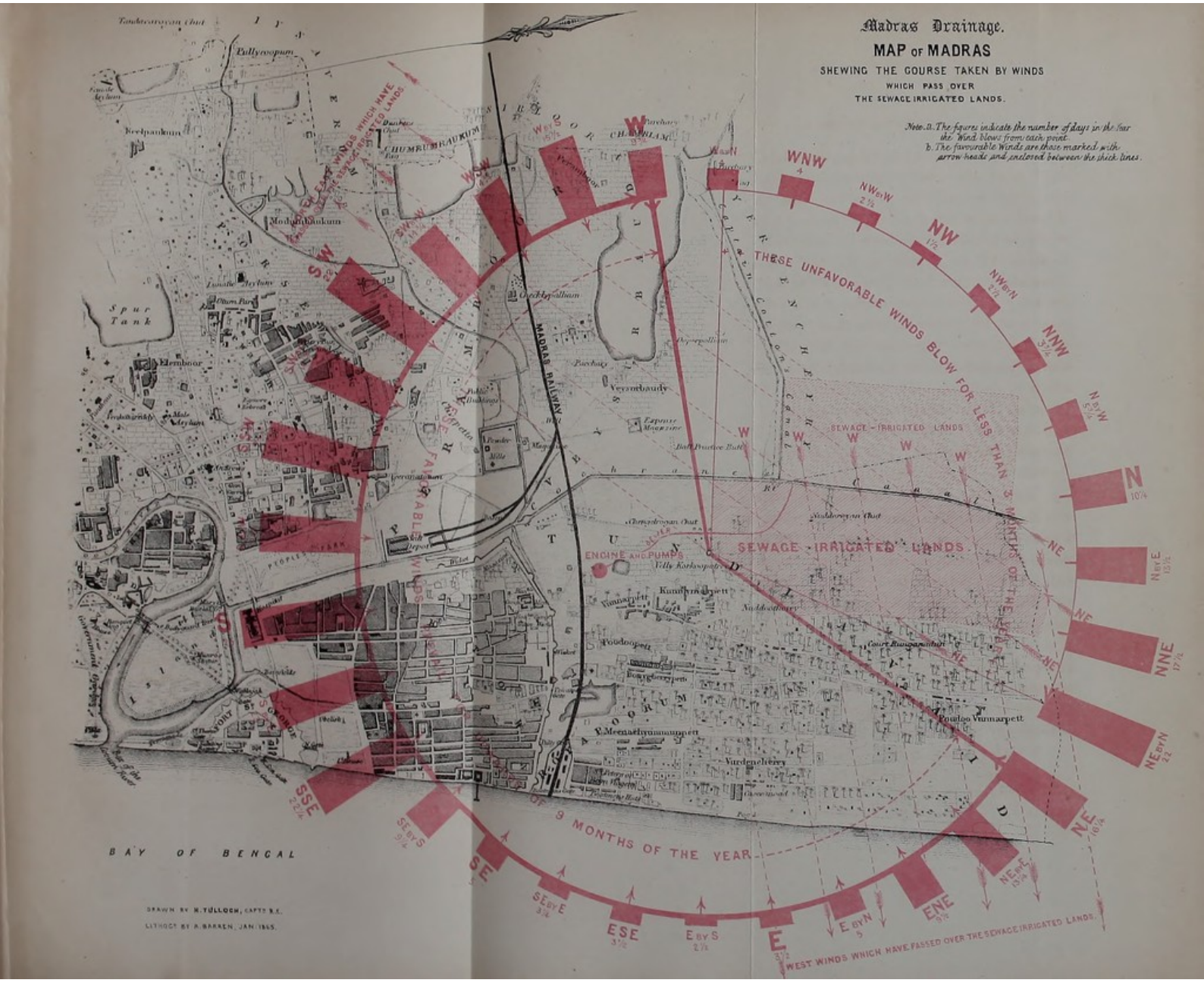
The accompanying Chart shows the number of days in the year the wind blows in Madras from each point of the compass. All those winds marked with arrows are winds which would convey the smell of the sewage away from Madras. The other winds would blow over the sewage lands to some one or other inhabited quarter of the town. Now, a glance will convince any one by how very much the favorable winds exceed the unfavorable ones. While the latter blow for less than three months, the former blow for more than nine months of the year. It must not be supposed that each wind blows *continuously* during the number of days marked in the Chart. What is meant to be shown is, that the total number of days in the year during which the wind blows from any one point of the compass amounts to that shown in the Chart. The winds N. E. by N. and N. N. E., which I have marked as unfavorable, are really in only a very slight degree so, for they would have to travel nearly two miles before they reached the nearest inhabited part of Madras, which would be the outskirts of Pursewakum. The nuisance, therefore, if there were any, which I altogether doubt, would, at all events, be so very slight as to be scarcely felt.

On the accompanying Map of Madras I have shown the position of the sewage-irrigated lands, and have projected the directions of the winds so that the course taken by each may be at once seen. The only winds, if any, which would be positively unfavorable, are those which blow from between W. by N. to N. by E., but, practically speaking, there are no winds from between W. to N. Only occasionally, for a day or two in each month of the year, does the wind blow from the points between these quarters. It never continues in them. To render this clear I have drawn the accompanying diagram which shows the number of days in every *month* of the years 1847, 1848, 1849 and 1850,* during which the wind blew in Madras from each point of the compass. It will be noticed how thinly scattered over all the months of the year are the days on which the wind blew from between N. and W.

I think it will now be admitted that no inconvenience will be likely to arise from the use of the sewage on the site I have pointed out. But should the Government have any doubt on the matter, it would be very easy to select a much better site by going farther away from Madras. It is a question of expense only, for the farther the land is situated, the longer must be the channel which conveys the sewage to it. I have merely chosen the nearest site on which I consider sewage might be applied without objection being made. My opinion is, that the sewage might even be used around the very spot on which it is pumped up from the cesspool without any nuisance to the inhabitants.

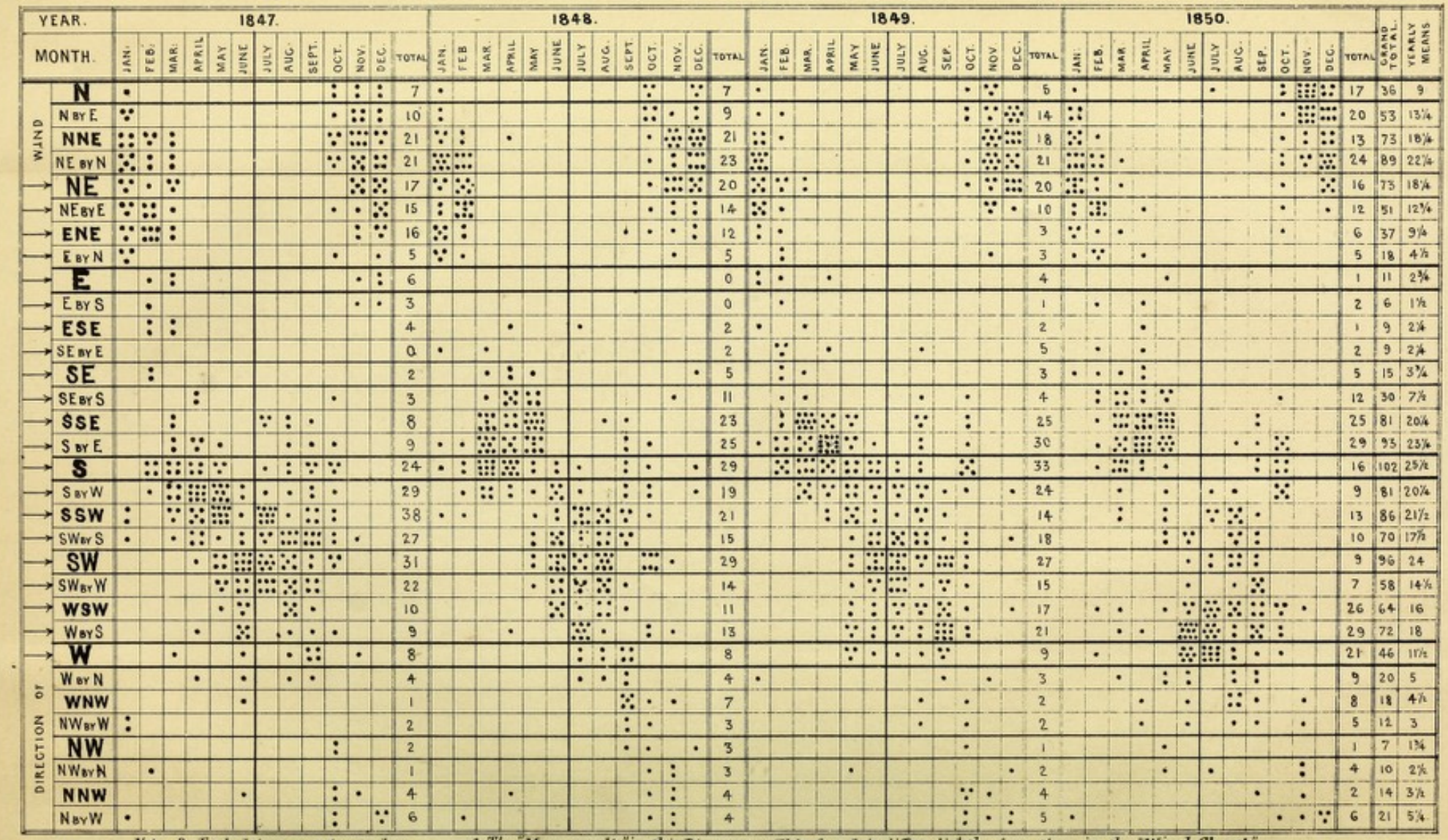
I had partly designed an Irrigation Sewer, but I subsequently decided not to complete it as it was essential to

* I have not *selected* these years, but the Government Astronomer (N. R. Pogson. Esq.,) gave me the records of them as being those which were in the most convenient form for reference. No records of later years have as yet been published.


Madras Drainage.
MAP OF MADRAS
SHEWING THE COURSE TAKEN BY WINDS
WHICH PASS OVER
THE SEWAGE IRRIGATED LANDS.
Note. a. The figures indicate the number of days in the Year the Wind blows from each point.
b. The favourable Winds are those marked with arrow heads and enclosed between the thick lines.
THESE UNFAVORABLE WINDS BLOW FOR LESS THAN 3 MONTHS OF THE YEAR
SEWAGE - IRRIGATED LANDS
ENGINE AND PUMPS
MADRAS RAILWAY
BAY OF BENGAL
WEST WINDS WHICH HAVE PASSED OVER THE SEWAGE IRRIGATED LANDS
DRAWN BY H. TULLOCH, CAPTN R.E.
LITHOGT BY A. BARRON, JAN. 1865.

Madras Drainage.

DIAGRAM SHEWING THE NUMBER OF DAYS IN EVERY MONTH OF THE YEAR THE **WIND** BLOWS IN MADRAS.
FROM EACH POINT OF THE COMPASS.

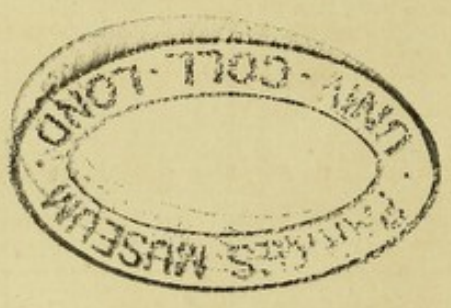


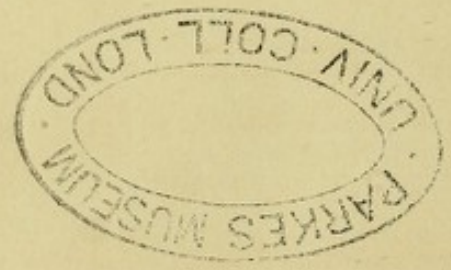
Note. a. Each dot represents one day.
b. The favourable winds are marked with arrow-heads.

c. The "Mean results" in this Diagram will be found to differ slightly from those in the "Wind Chart". The former are averages of 4 years observations, and the latter of 5.

A. BARREN, LITH. JAN. 1865.

DRAWN BY H. TULLOCH.


PARKES MUSEUM
UNIV. COLL. LOND.


PARKES MUSEUM
UNIV. COLL. LOND.

know first what site the Government might select for the utilization of the sewage. The great advantage of using the sewage will be the saving effected by not having to construct the Outfall Sewer, a work that will cost about three lacs of Rupees. Besides this, the sale of the sewage may be expected to realize a considerable sum.

Before going on to state the cost of this Project, I beg very respectfully to urge on the attention of Government the great importance of the question of utilizing the sewage of Madras. Every town in India has an interest in its decision, and could it be proved that the sewage of towns could be profitably and safely applied to land in India, an incalculable benefit would be conferred on the whole country.

Cost of the works.

The following is a List of the quantities of work to be done, and the rates at which they are calculated :—

Quantities.	Description of work and rate.	Amount.
	Main Drainage.	
Cub. ft.		Rupees.
1,337,751	Brickwork in hydraulic cement, at 6 As. per cubic foot	5,01,657
1,718,121	Concrete, at 2 Annas per cubic foot	2,14,765
Sq. ft.		
1,053,100	Asphalting, at 15 Rupees per square of 100 feet	1,57,965
7,000	Plastering, at 2 Rupees 8 Annas per square of 100 feet	175
Run. ft.		
104,928	Invert Block, at 1 Rupee 8 Annas per running foot	1,57,392
Cub. ft.		
27,106	Ashlar Granite, at 1 Rupee 8 Annas per cubic foot	40,659
Cub. yds.		
529,169	Earthwork, including excavation, re-filling, re-making road and every expense, at 1 Rupee 4 Annas per cubic yard	6,61,461
991	Tunnelling, at 7 Rupees per cubic yard	6,937
33,281	Embankment, at 1 Rupee per cubic yard	33,281
20	Gravel, at 1 Rupee 2 Annas per cubic yard	23
Cub. ft.		
809	Teakwood, at 3 Rupees 4 Annas per cubic foot	2,629
Sq. ft.		
4,203	Galvanized iron netting, at 6 Annas per square foot	1,576
lbs.		
31,614	Wrought iron, at 150 Rupees per ton	2,117

Quantities.	Description of work and rate.	Amount.
Number.		
1,104	Rivets, at 1 Anna 6 Pie each	104
336	Cast iron Ventilators, at 30 Rupees each	10,080
336	Trap Doors, at 140 Rupees each	47,040
263	Ball Valves, Sluice Valves, Sluice Gates with pipes complete for each Flushing Reservoir, at 90 Rupees	23,670
Tons.		
6,258	Granite Boulders at 2 Rupees per ton	12,516
	Total Rupees...	18,74,047
	Street Drainage.	
Run, ft.		
577,490	Six-inch glazed earthenware pipe drains, including digging, laying down, jointing, filling up, and every expense, at 1 Rupee 4 Annas per running foot...	7,21,863
61,400	Nine-inch do do do at 1 Rupee 12 Annas per running foot	1,07,450
2,800	Twelve-inch do do do at 2 Rupees 4 Annas per running foot	6,300
Number.		
214	Man-holes and Side-entrances for the nine and twelve-inch pipes, at 500 Rupees each	1,07,000
	Total Rupees...	9,42,613

I have thought it best to show clearly the exact quantities of work and the rates at which they are calculated, so that an opinion may be formed by the Government on the Estimate.

For sewerage works none but the best procurable materials should be used. Admirable steam-pressed bricks have already been made in Madras—sufficiently good for any engineering purpose. I propose to use bricks similar to these for the Madras sewers. Hydraulic cement can be made wherever lime and clay are to be had, and I have no doubt excellent cement will be produced when the time comes to begin the works. In London, brickwork for sewers, when the bricks are picked stocks and laid in Portland cement, costs under a shilling a cubic foot; but such brickwork will not be attainable in Madras. Brickwork with picked stocks in blue lias lime costs under 9*d.* a cubic foot. I have taken 9*d.*, or 6 Annas, as the rate for the Madras sewers.

In London, concrete, composed of blue lias lime and clean ballast, costs under 3*d.* per cubic foot. I have taken 3*d.*, or 2 Annas, as the rate for Madras. Hitherto, I believe, concrete has cost somewhat more than this; but it has been made in such small quantities, that it is difficult to say what the cost will be when it is manufactured on a large scale.

I think it will be necessary to coat the interior surface of the sewers with asphalte, and I do not apprehend any difficulty in the work, as the brickwork will all be built in blocks on the surface of the ground before it is laid in the sewers.* The cost of the asphalte coating will, I think, be covered by the rate allowed for it, viz., 15 Rupees per square of 100 feet.

* "The whole of the brickwork executed under this contract shall be built in blocks above ground previously to being put into position in the sewers and other works. Each block shall be at least 18 inches long by 12 inches high, and there shall be a sufficient number of boxes provided by the contractor, to admit of the blocks remaining in the boxes for at least two days. As soon as each block has been built, the joints on that side of it which shall correspond with the internal surface of the sewers, or other works, shall be scraped and kept open to the depth of not less than one inch. After the block has been removed from the box, and after the hydraulic cement has become perfectly hard and set, that side of it which shall correspond with the internal surface of the sewer, or other work, shall be coated with a coating of asphalte not less than a quarter of an inch thick. The asphalte shall be poured in a melted state into the joints, so as completely to fill them, and the coating when finished and dry shall be perfectly smooth and even. The asphalte coating shall in no case be laid on until three days have elapsed from that on which the block was removed from the box. The asphalte shall be boiled with linseed oil in proportions to be decided by the Engineer, and no sand or other material shall be mixed with it.

The brickwork shall be executed in the best manner, the blocks laid evenly and uniformly to the curvature of the moulds and centres, in neat, close, and regular joints, kept straight or regularly curved as the case may be, with the direction, and parallel with the rise of the sewer. The brickwork in the blocks generally to be in old English or other bond as may be ordered, and to break joint correctly with the bricks underneath. The joints of the blocks with each other on the internal surface of the sewer, or other work, to be finished off smooth with melted asphalte to the depth of at least one inch. The joints of the bricks with each other, or of the blocks with each other, shall not exceed 3-16ths of an inch in thickness."—*Extract from the "Specification" for the Sewers.*

It is most essential that the inverts of the sewers should be laid with the best material. They are exposed to much more friction than the other parts of the sewers. For smoothness of surface and for durability there is nothing to equal the glazed earthenware blocks which are now manufactured and used in such large quantities in England for the inverts of sewers. They have been laid down in the London sewers at 2 shillings per running foot. I have allowed 3 shillings, or 1 Rupee 8 Annas, per running foot for Madras.

Earthwork, including digging, re-filling, tamping, shoring, pumping, keeping the works clear of water, re-making roadways, and every expense whatsoever, has been done for the London sewers at 2*s.* and 6*d.* per cubic yard. There is no reason why this rate should be exceeded in Madras.

Six-inch glazed earthenware drain pipes have been laid down in London at 2*s.* per running foot, including digging, re-filling, and every expense whatsoever. Nine-inch pipes have been laid at 2*s.* and 6*d.*, and twelve-inch pipes at 3*s.* per foot run. The rates I have adopted for the Madras sewerage are,—for the six-inch pipes, including all bends and junctions, 1 Rupee 4 Annas ; for the nine-inch, 1 Rupee 12 Annas; and for the twelve-inch, 2 Rupees 4 Annas per running foot. The use of none but the best earthenware pipes should be contemplated. It would be folly to use country-made pipes as they are manufactured by the potters at present.

I have assumed that each Man-Hole or Side-Entrance for the street drains will cost 500 Rupees. The quantities of materials will differ according to the position of each, but I think the above will be found a near approximation to the cost.

The other items in the preceding estimate are of small amount, and it is not necessary that I should refer to them, as

any slight alteration in the rates for them will affect the total cost of the works in only a slight degree.

Some land will have to be bought up for the works, and the value of this has been ascertained, in communication with the Collector's Department, at 25,340 Rupees. A few small buildings in the line of the sewers will likewise have to be purchased. The cost of these will be 20,000 Rupees. The cost of the engine and pumps (72 Horse-power) has been calculated at 1,500 Rupees per horse-power, delivered in Madras, or altogether to 1,08,000 Rupees. The Pumping Station, and works in connection with it, (including expenses of erecting the machinery) will, it is calculated, cost 70,000 Rupees. There are no plans for this work, as I have already explained, but I believe 70,000 Rupees will cover all expenses.

The total estimate for all the works is as follows :—

	Rs.
Main Drainage	18,74,047
Street Drainage	9,42,613
Land to be purchased	25,340
Buildings do.	20,000
Engines and Pumps of 72 Horse-power, at 1,500 Rupees per horse-power	1,08,000
Pumping Station, including cost of putting up machinery, and other works	70,000
Total Rupees...	30,40,000
Add about 10 per cent. for sundries and contingencies	3,10,000
Total Rupees...	33,50,000

If Government decide, as I trust they will, that the sewage shall be utilized for agricultural purposes in the neighbourhood of the Pumping Station, the cost of the Outfall

Sewer, about three lacs of rupees, will be saved. An Irrigation Sewer will, in this case, have to be built, but its length need not be more than one-third that of the Outfall Sewer, and its dimensions need not be so great. The cost of the Irrigation Sewer may be put at about a lac of rupees. Deducting the cost of the Outfall Sewer (about 3 lacs of rupees) from the amount of the above estimate (33½ lacs), and adding the cost of the Irrigation Sewer (say a lac of rupees), the total of the estimate becomes 31½ lacs.

It will be seen that I have allowed the large margin of upwards of 3 lacs (10 per cent. on the estimate) for unforseen contingencies.

Establishment for superintending the works.

The cost of the establishment for superintendence will probably be as follows :—

	Rs.
1 Mechanical Engineer specially brought out from England to superintend the working of the engine and to keep the accounts	400
2 European or East Indian Engine-drivers, at 50 Rupees each	100
4 trained Firemen, at 15 Rupees each	60
4 ordinary Firemen, at 8 Rupees each	32
25 men (mostly sweepers) to look after the sewers and pipe drains, and to be available generally for any work, at 5 Rupees each	125
1 Storekeeper and Accountant	50
1 Clerk	25
4 Peons, at 6 Rupees each	24
Monthly cost, Rupees...	816
	12
Yearly cost, Rupees...	9,792

If 5 Rupees yearly represent a Capital of 100 Rupees, the above sum for superintendence would represent a Capital of (9,792 × 20 =) say, 2 lacs of Rupees.

Cost of fuel, oil, tallow, &c.

I think it may fairly be assumed that for many years to come, the quantity of sewage will not exceed 10 gallons per diem per head of the population. The total quantity of sewage to be raised by the pumps daily, taking the population of Madras at 430,000, would, therefore, be 4,300,000 gallons. Good engines of the largest size (of about 200 or 300 horse-power) lift from 2 to 3 million gallons of water a hundred feet high with a ton of coal. Small engines (such as those proposed for the Madras Drainage) would not lift more than half this quantity, or say $1\frac{1}{4}$ million gallons a hundred feet high. This is equivalent to more than $4\frac{1}{2}$ million gallons 27 feet high, which is the height to which the pumps will have to raise the sewage. About a ton of coal, or say $1\frac{1}{2}$ tons at the outside, will, therefore, be consumed daily in Madras. The cost of coal, if imported direct from England and not purchased in the local market, may be taken at 20 Rupees a ton. The yearly cost for fuel will be (365 × 30 =) 10,950 Rupees.

To this sum we should add, say 2,050 Rupees for oil, tallow, and other sundries, which would then make the total yearly expenditure about 13,000 Rupees. This would represent a Capital of (13,000 × 20 =) say $2\frac{3}{4}$ lacs of rupees.

Cost of repairs.

If the works are properly executed in the first instance, and a sufficient establishment, such as that proposed, is maintained to look after them, the repairs ought to cost little or nothing. There are sewers at Home which have cost nothing for repairs for years after they have been laid down. But I will assume that the repairs every year will amount to $\frac{1}{2}$ per cent. on the cost of the works, *i. e.*, on $31\frac{1}{2}$ lacs, supposing that the Outfall Sewer is not built. This will be equivalent to, say, 16,000 rupees yearly, or to a Capital of about $3\frac{1}{4}$ lacs.

The total estimate, then, under all heads, will be as follows:—

Cost of works	31½ lacs.
Superintendence	2 „
Fuel and sundries	2¾ „
Repairs	3¼ „
	39½ lacs.

The cost of dry conservancy and of sewers compared.

We are now in a position to compare the cost of sewerage with that of Dry Conservancy. In my estimate above of 39½ lacs of rupees, I have included every possible charge. I will even assume now that the works may cost as much as 50 lacs or half a million pounds sterling. And what will the rate-payers receive for this sum? All liquid refuse will be removed from the precincts of their dwellings and will be utilized on land. Ultimately, I have no doubt that the value of the sewage for agricultural purposes will repay the cost of maintenance, but I will not assume this now.

The Estimate I prepared of the cost of Dry Conservancy* was 75 lacs of Rupees. But I did not include the cost of procuring clay, which amounted to 31 lacs,† and I excluded all cost of repairs and a number of other items.‡ The calculations based on the enquiries made into the cost of Dry Conservancy by the Sanitary Commissioners,‖ brought up the cost of this system to 258 lacs. Let me suppose, though for argument's sake, that a million pounds sterling will cover all expenses. We then have half a million pounds sterling for a system of sewerage by which all liquid refuse is removed, and a million pounds sterling for Dry Conservancy by which only urine and ordure are removed, which together amount to *one hundredth* part of

* Vide Page 38.

† Vide note to Page 39.

‡ Vide Pages 38 and 39.

‖ Vide Pages 40 and 41.

the sewage. So that it will cost at least twice as much to remove urine and ordure only according to the Dry Conservancy system as it will to remove a hundred times their amount of sewage by the Sewer system.

Cost of Drainage considered with reference to the value of house property.

It has been urged that the cost of draining Madras according to this Project will amount to as much as the value of all the house property in it, and that it will be better to remove the town bodily, as the Americans remove their houses, than to attempt to drain it. It is best to meet arguments of this kind by facts. The value of a house is usually considered equal to 30 years' rental. The number and yearly rent of all the houses in the town may be obtained by any one from the Municipal Commissioners' Office, and the value of all the houses will be found to be 850 lacs of rupees or $8\frac{1}{2}$ million pounds sterling. Half a million pounds sterling (the assumed cost of this Project) is not 6 per cent. on the value of the houses at present, and a good system of water supply and drainage will raise their value in the course of a few years by at least twenty per cent. Money laid out in water supply and drainage works is merely capital sunk to improve house property. The inhabitants recover the outlay by the enhanced value of their houses.

Cost of Drainage must always be great.

There is an impression that Madras can be drained for a very small sum of money. I have no hesitation in saying that the idea is absurd. It is possible to have a cheap system of water supply, but it is utterly impossible to have a cheap system of town drainage. In supplying a town with water, you may carry a few pipes to a few central stations and make the inhabitants fetch their water from them. But in draining a town you must carry a pipe from *every single house* in the town, without exception, to some one central spot. The length of drains in the latter instance becomes enor-

mous. Whatever scheme of drainage is adopted for a town, the length of the sewers and pipes must be almost exactly the same. In the case of Madras, there must be about 140 miles of sewers and pipes, or, if not, some parts of the town will be left undrained. For whatever sum of money 140 miles of drains can be laid down, for that sum only, and for no less, can Madras be drained.

Contractor for works.

It is necessary for me to add only that the success of this, or of any Project for the drainage of the town, will depend, in a great measure, upon the manner in which the works are executed. Contractors who have had practical experience in sewerage works will have no more than the ordinary difficulties to contend with in the building of the sewers and the laying down of the pipes for Madras, but should any one attempt the work who is unacquainted with town drainage, certain failure will overtake him. In the present day, contractors in England have attained great skill in the execution of sewerage works, and I, therefore, venture to recommend that, when the Government shall have come to a decision on the subject, they should invite tenders for the Madras Drainage Works in London, and accept not necessarily the lowest tender, but the tender of some well-known builder who has already proved himself competent, and who possesses the requisite amount of capital for the undertaking.

H. Tulloch,

Captain, Royal Engineers.

Bangalore,
December, 1865.