dale, with disinfectants in them; but a week after sending in his report, seeing a paper by Dr. Haviland on this very subject, in which he spoke of what appeared to be the marvellous result on the health of Halifax from the adoption of the Goux system—and he should recommend any one interested in the question to read this paper—he determined to look further into it. He next saw a report by the Goux Company, in which the opinions of several medical men were brought forward, giving their experience in favor of the Goux closets, especially at Aldershot, and he, therefore, determined to inspect it for himself. It was stated in the report that there was then a heap of manure of about 40 tons giving off no smell at all, and he, therefore, accompanied by the Inspector of Nuisances and a large builder in the town, went over to examine into it. The Inspector of Nuisances rather laughed at the idea of the pail-system, and the builder was opposed to it, because he thought he might probably have the contract to drain the town. They went all round the place, and visited nearly every closet in the north camp, and though it was a very wet day in November, they did not find what could be called a nasty smell in any one, and, in the great majority, if they had been taken in blindfold, they would never have thought that they were in a place of the kind at all. Those who accompanied him were of the same opinion, and the builder entirely gave up his opposition, and had adopted one of these closets in his own workshop, and consoled himself with the idea that instead of getting £500 out of the drainage he might get £200 out of the Goux closets. When at Aldershot he asked an old soldier, whom he saw

coming out of one of these places, if there was ever any smell in the summer, and he replied that there was sometimes a little, but not half so much as in 'them stinking water-closets in the south camp.' He was not satisfied with this, but went to Halstead, in Essex, a small town where there had been an injunction against turning sewage into the river, and which had adopted the Goux closets. He was informed by the Surveyor that there were 170 at work, and that there were no complaints whatever. Since then he had received a letter from the Medical Officer of Health giving the same testimony, though he said he liked the water-closets best, because they were less trouble. He was informed that the tubs were lined with a mixture of horse-droppings collected from the streets and sifted ashes, and he found the places where this was prepared smelt much like a stable, but nothing more. He went into about 50 of the closets, some new and some old, and in only one or two instances was there anything like a smell, and that was where the tubs had been allowed to overflow. They were collected about once or twice a week by men in a waggon; no annoyance was caused." . . . . . .

CHAPTER XIII.

"Now there was beneath the Altar of Solomon's Temple a certain cave, whereby the filth and uncleanness were carried down into the valley of Kedron, and the gardeners paid so much money as would purchase a trespass offering for fertilizing their gardens therewith."—*Mishna. Jewish Tradition.*

Having considered the mode of collection and house-to-house removal of nightsoil, we have now to consider how it is to be disposed of, whether by conversion into poudrette, or some other form of dry manure; by direct application to the soil as a stimulant to cultivation, or simply by burying it, so as to dispose of it with the least trouble and expense.

Years ago attempts were made by a gentleman (Gilbert Hickey, C.E.), since deceased, to utilize nightsoil by converting it into gas for illuminating purposes, the dry residue being a perfectly harmless inodorous poudrette. These experiments were conducted at the Alipore Jail, and, apparently, with great success; but from want of capital or means to push the invention, the experiments never went beyond that stage, and the inventor shortly after died, leaving his experiments incomplete. I need not do more than allude to the elaborate systems in use in Birmingham and other large towns in England, where the filth is converted into valuable manure or into Port-

land cement by the aid of extensive and expensive machinery; but I may shortly notice what is known as the Rochdale system, as it has, with certain modifications, been already adopted by the municipal authorities of some Indian towns, notably Poonah, in the Bombay Presidency.

The Rochdale system is thus carried out:—"The ashes collected from the houses are carried out to the manure depôt, and are there screened by machinery. The fine ashes are then spread out in deep layers and into a series of trenches made in these layers, the contents of the excrement pails are emptied and covered with fine ashes. Sulphuric acid is then added in the proportion of 25lbs to one ton of the excrement to facilitate drying. The proportion of fine ashes to excrement is thirty-five of the former to eighty of the latter." This process, however, is said to have been so expensive that, latterly, the pail contents were merely mixed with the house refuse and ashes, and great difficulty is said to be experienced in getting rid of the mixture, which is pronounced to be most offensive.

The Poonah system is called by the local authority the 'sun-drying process,' and is thus carried out:—"The street and house refuse collected from the dust-bins of the city are carted out and burnt into ashes. Beds are formed with floor made of '*murum* or other hard substance to receive the nightsoil. The beds are eighteen feet square and one foot deep. A layer of ashes one inch thick is first spread over the floor of the beds, and nightsoil is then poured on about five inches deep, and is covered over with another layer of ashes also one inch thick. It is then allowed to remain for twenty-

four hours in the sun, during the fair season, and for three days under sheds, during the rainy season. The nightsoil is, after the lapse of the time mentioned above, stirred and well mixed with the ashes spread above and below it, and a fresh layer of the latter, half an inch thick, put on, when it is allowed to lie for three days further in the fair season, and eight days during the rains. The mixture is then again stirred, taken out of the beds and spread on dry open ground exposed to the sun, to complete its drying. It is then stored in heaps for sale, and is in dry weather fit for immediate use. In the rainy season the drying has occasionally to be done under cover, and, consequently, the process occupies as many as twelve days, whereas in the cold season it takes six, and in the hot season only four days.

It is said that the manure thus prepared is so much appreciated by cultivators that payment is frequently made four to six months in advance to secure a supply.

The financial result is certainly encouraging, the total cost having been Rs. 18,000, and the receipts Rs. 5,000, per annum. The actual cost of removing the filth from the town, an unavoidable charge it must be borne in mind, was Rs. 14,400. So that the net profit, on the actual expense of manufacture, *viz.*, Rs. 3,600, was Rs. 1,400, or nearly 39 per cent.

Of the various modes of applying the excreta directly to the soil, we may first consider the system which has been adopted by the Calcutta Suburban Municipality, not because it is by any means a complete or thoroughly satisfactory system, but because it fulfils the first great necessity, and overcomes what is always the first great difficulty, in introducing any system of scavenger-

ing into an Indian town, whilst it also possesses other undoubted advantages, and is, I may say, the first practical step towards the utilization problem.

The system is the burial of the nightsoil in trenches in garden grounds, as far removed as conveniently may be from human habitations, and the subsequent cultivation of the ground so used. It differs from the Bengal Jail system mainly in the size and depth of the trenches, the municipality being compelled from the difficulty of obtaining suitable lands within a reasonable distance of the town to make the trenches as deep as possible to economize space. That this is a weakness in the system I unhesitatingly admit, but it cannot at present be avoided, and that the evil is not so great as some sanitarians argue, will, I think, be proved by the following result of the operations.

A series of examinations were made by me from time to time to test the deodorizing and decomposing power of the soil, with the following satisfactory results :—

1*st.*—Ground used for the burial of nightsoil in the month of April, was opened up in the beginning of November following. To a depth of two feet from the surface the soil was ordinary, stiff alluvial earth ; the next or nightsoil layer, consisted of a loose rich, black mould, without any offensive smell or any trace of fæcal matter, quite fit for garden purposes. After a few days' exposure to light and air, it was undistinguishable from the surface soil.

2*nd.*—Trenches used in all May were dug up, the nightsoil layer being a bluish black mould, free from any smell or appearance of fæcal matter.

3*rd.*—Trenches used in June and July were not sen-

sibly different from the last, except that traces of fæcal matter, chiefly fibrous, were visible throughout the mass.

4th.—Trenches used in August were somewhat offensive when opened, and fæcal matter was found in masses still unconverted.

5th.—The trenches recently filled in November were perfectly inoffensive, until the layer of nightsoil was exposed by the spade, when an offensive odour was perceptible close to the trench. But the mass was perceptibly undergoing a change.

I may remark that every effort is made to mix the soil with earth as dry as possible when the trenches are being filled, and that the last eighteen inches is filled up with earth alone.

The advantages gained, therefore, are, that the filth is effectually disposed of without causing nuisance; the lands employed are gradually raised—a great consideration in a low-lying locality, and their productive powers are enormously increased. I do not overlook the fact that sanitary authorities in India have, to a certain extent, condemned the practice of burying nightsoil; and I find that the Army Sanitary Commission (1869), remarked,—"that the practice of burying the mixture of earth and excrement must result in fouling large areas of ground," for that, "even after careful mixture of excreta with earth, the mass, when buried, gives out offensive vapours in damp or rainy weather." They also say: "It still may be taken as showing that, in India, the earth process and subsequent burial are inadequate for the requirements of health, at least in the case of large fixed populations; and *that if this process is to be continued for such populations, it must be modified,*

and brought more in accordance with natural laws." This is, it appears to me, the pith of the whole argument, the necessity of 'bringing it more into accordance with natural laws.' And this is only to be done by cultivation, and applying the excreta to the soil in the manner most convenient for its rapid absorption and assimilation by growing vegetation. "It is only the action of the living and growing vegetable which recomposes the products of decomposition and carries out to its consummation the process of disinfection, even as it is only through plant-life that we can reach the goal of utilization." The roots of plants are actively and unceasingly at work absorbing the products of decomposition as they are evolved, and thus preventing their escape to the surface.

At the commencement of the working the owners of the lands who had, after considerable persuasion, leased them out to the Municipality, complained that the standing fruit-trees were being injured by the burial of soil close to their roots; but, on careful investigation, these apprehensions were found to be groundless. The only instances where the trees had really suffered were distinctly traceable to the excessive cutting of their roots in digging deep trenches alongside of them. On the contrary, they largely benefited as a rule, and in many cases old trees recovered, put out new flushes of leaf, and began to fruit, though previously barren.

After the trenches have been filled, closed, and the ground has settled a little, it is dug over regularly and cultivated with jute, sugarcane, fodder, maize, guinea grass, reana luxurians, or lucerne. Carrots have also been found a useful crop for horse-fodder, but, as a rule, *root*

crops are not suitable for first cropping on such richly manured lands. Jute and coarse strong feeding grasses are better for the first crop. Jute, which seldom attains a great height in this part of Bengal, reaches twelve and-a-half to thirteen feet, and is proportionately stout, with good, fine fibre, fit for the manufacture of Hessian cloths. Sugarcane yields a fair heavy crop, and all the grasses are entirely successful.

The following will be found a convenient rotation for working nightsoil grounds over a series of years, the main principles to be observed being—

1*st.*—The occupation of the land for a sufficient time for trenching in the filth.

2*nd.*—The planting of such crops as are strong coarse feeders, and which consequently exhaust the richness of the soil, followed by those less exhausting.

3*rd.*—The regular succession of perpendicular rooting and horizontal rooting crops.

4*th.*—Not repeating the same crop in the same ground.

5*th.*—Regular periodical retrenching.

ROTATION.

From	1st Feby.	to 31st May,	4	months,	Trenching.
„	1st June	to 31st August,	3	„	Fodder maize.
„	1st Sept.	to 30th Nov.,	3	„	Country carrots
„	1st Decr.	to 31st March,	4	„	Trenching.
„	1st April	to 31st May,	2	„	Fallowing.
„	1st June	to 30th Sept.,	4	„	Jute.
„	1st Oct.	to 31st January,	4	„	English carrots.

Another plot of ground would be trenched alternately with the last, thus—

From	1st June	to 30th November,	6	months,	Trenching.
„	1st Decr.	to 31st May,	6	„	Guinea grass.

And another portion, as follows:—

From	1st Feby.	to 31st May,	4 months,	Trenching.
„	1st June	to 30th April,	11 „	Sugarcane.
„	1st May	to 31st August,	4 „	Trenching.
„	1st Sept.	to 31st January,	5 „	Carrots (English).

Of course these dates cannot always be strictly adhered to, but must vary according to the earliness or lateness of the seasons in different parts of the country.

Where the local markets are badly supplied with English and country vegetables, they may be grown with the greatest success on ground thus manured, and are far superior both in size and quality to the ordinary garden vegetable.

The late Dr. Fawcus, Superintendent of the Alipore Central Jail, who took great interest in this subject, advocated the cultivation of plantains, and was of opinion that a square mile of ground so cultivated would yield an annual income of Rs. 300,000. I extract the following from a memorandum on the subject:

"The cultivation of bananas requires little or no knowledge of farming, and very little labor or care. All that has to be done is to plant in rows, and manure well the interspaces. I know from experience that human excrement is especially suited to plantains, and that, when well manured with this, they yield enormous crops, and do not require the usual triennial transplanting."

The principal objection to this form of cultivation is the long time that the ground is occupied by the plants. Where ground is plentiful and need not be used oftener than once in three years, plantain or banana cultivation would be undoubtedly profitable.

The following testimony as to the value of nightsoil

earth is given by an experienced horticulturist, Mr. Superintendent Lynam, of the Calcutta Police:

"I now give you my promised report on the night-soil earth. I must say that, as far as I have experimented, it has been a great success. I have tried it on more than two hundred rose plants, and on every plant there was a marked improvement both in vigorous growth and profusion of flowers; and moreover, there is a second set of flowerbuds forming after the first set was cut away. This I never had before. What pleases me with it most is, that it is not a heating fertilizer, and therefore does not unduly stimulate the plants. It is certain to improve roses in bad health, and I must say that a very valuable manure has been wasted up to the present time. It would be admirable for tea plants: it should not be put directly to the roots, but the surface soil should be loosened, the earth mixed with it and watered copiously a day or two after. I may remark that, after exposure to the air for a short time, it loses all its offensive qualities, and a *mali* may handle it without knowing it to be other than ordinary soil."

The next question for our consideration is, whether the collection and utilization of the filth of a town can be made to pay the cost of cleansing and removal, or yield any substantial return to the town for the outlay incurred; and this is one which cannot, I fear, be satisfactorily answered so far as Bengal is concerned, despite English or Continental precedents and the theoretical calculations so confidently put forward by Mr. Buck, the Director of Agriculture and Commerce, N. W. P., and even of the actual experiences of the few Indian towns that have succeeded to some extent in profitably disposing of their filth.

Before we can confidently look to the utilization of excreta as manure in a profitable sense, we must expect a total alteration in the feelings, habits, and prejudices of the cultivating classes of the province. There are only two forms in which hand-removed excreta can be utilized, *viz.*, as a prepared manure (poudrette or artificial guano),* divested of all offensiveness, and presented in quite a new form in which its objectionable origin is so cloaked and disguised as to give the cultivator a fair excuse for ignoring it, or it must be removed by the cultivator himself from central places of deposit, and in its undisguised form of nightsoil merely mixed with earth or ashes sufficiently to retard decomposition, and make a sufficiently *dry* compost for loading and handling.

The advocates of the pail-system generally claim that it can be made to pay; and Professor Corfield says: "The evidence generally shows that this plan can be made to pay, and indeed generally *does* pay its cost at any rate. In the town of Groningën it is said the yearly profits amount to about £1,600; in Antwerp to £2,700; at Ostend to £700. In Strasbourg it is said the sale of manure covers the cost of removal; in Stockholm the expenditure is £35,000, and the returns £33,000. Nottingham, spending £6,000, gets a return of £4,000; and Salford is said to cover its expenses by the receipts."

* *Note.*—"Mr. Hughan has brought forward a new fertilizer, termed 'Huano,' formed by a combination of nightsoil with phosphates. Sulphuric acid is used as in the manufacture of common phosphates. The nightsoil serves to reduce the phosphates to a proper pasty condition for the action of the acid, which is then applied and sulphate of lime or plaster of Paris is then formed, and solidification and deodorization of the whole mass takes place."—(*American Government Reports.*)

This seems encouraging, and it might be argued that if it can be made to pay, as shown in other places, why not in Bengal; but there is a vast difference in the local circumstances and conditions that cannot be overlooked. The towns mentioned above are situated in agricultural countries, where the land is limited in area, and most valuable, where it is scientifically cultivated so as to yield the utmost possible return, and where there are no religious or caste prejudices to interfere with the handling and use of any manure so long as it can be made *to pay*.

But again, the example of China is often quoted, and, as an instance of thrifty economy of material and well-directed industry, with justice; but beyond this there is no parallel. The Chinaman cultivates with the most laborious care every yard of ground, every slope, every rocky shelf, capable of holding up a few cubic feet of soil. He manures every individual plant, and makes it yield its utmost. He has no silly prejudice against handling excretal matter, but preserves the waste products of his body with as much care as if they were (which indeed they are to him) the most valuable property. So minutely careful is the Mongol cultivator in this respect, that he carefully preserves the very clippings of his pigtail and the hair shaved from his body, and applies it as manure, a pinch being inserted into the ground with each seed or plantlet. "Indeed, it is only by means of this exceeding economy that the inhabitants of so densely populated a country can sustain life."—*Wood.*

I will only refer shortly to the economic results of filth utilization in this country as carried out at Poonah (the process of which I have already described) and other up-country towns. The cost of scavengering the

town of Poonah is Rs. 18,000, including the preparatory process; the return from sale of poudrette is Rs. 5,000. The cost of conservancy at Allahabad is Rs. 46,000,—*i. e.*, removal of sweepings Rs. 22,000, nightsoil Rs. 24,000. The *value* of the refuse is given as Rs. 13,800, but it is not asserted that any such return has actually been received. This is an assumed value given by Mr. Buck, the Director of Agriculture and Commerce, in a memorandum submitted to Government and circulated throughout the country for information. Mr. Buck, however, states, that at Farukhabad as much as Rs. 25,000 per annum *has been paid* for the nightsoil of the town by market gardeners of the Kāchhi caste.

The case of Farukhabad is very striking. Mr. Buck states, that "the city is divided into blocks, and the nightsoil of each block is the hereditary property of a family of sweepers or mehters. Each family collect the nightsoil in pits during the year, and in the month of October carry it out on backs of buffaloes and donkeys to the market and gardeners' lands. At Agra the receipts from sale of manure were only Rs. 3,000, besides the quantity used to manure fourteen acres of land; and at Cawnpore they amounted to 4,000 to 5,000 rupees.

The undoubted success obtained in growing crops of all kinds on lands so treated must sooner or later force itself on the mind of the Bengal cultivator; and the existing prejudice against the use of land so enriched will, there is every reason to believe, gradually die down before the attractive picture of profits to be obtained from its use. But for some time to come these profits must be cultivator's profits, and not profits to the town. There the profit must consist in the improved health and

comfort of the people, and in the improved value of the lands so enriched. We have first to induce the cultivator to accept the manure, and use it; to gradually create a demand for it; its value once fairly proved and established, and a healthy competition aroused, we may then look for a return of profit to the town from its extended sale.

But to effect this the attention of the cultivating classes must be attracted, and their interest aroused, in the benefits to be derived from the use of such manures; and the question how this is to be done is worthy of consideration; perhaps in this respect a little example is better than a great deal of precept:

> "Example is a living law, whose sway
> Men more than all the written laws obey."—*Sealey.*

And in this view municipal farms, judiciously situated in the outskirts of towns, and carefully conducted, would do much to prove to the native mind the truth of these theories; but there is another method which, while it would entail little expense on municipalities, especially those which have their own printing-presses, would in these days of widely diffused primary education undoubtedly aid in spreading abroad amongst the cultivators a knowledge of the subject and would arouse a spirit of enquiry, *viz.*, the distribution of little pamphlets, or papers printed in the vernacular, and telling in a simple and popular form the wonderful results obtained in various places by the use of such manures. Such papers, if judiciously written in a form to interest, would be read in many a raiyat's family by the boys on their return from the patshala, for the edification of their perhaps unlearned

parents or uncles, and to display their own proficiency, and in the verandah of the *chundi mundop*, or under the shade of the bokool tree, where village gossips and village politicians congregate to discuss the prospects of the crops and the last rumour of a new *taccus*. To those who have had no insight into the home life of the Bengali peasant, and who perhaps fail to picture to themselves the probability of such papers being read, and intelligently discussed by those whom they—it may be—regard as ignorant boors, caring for nothing but rice and their daily rice, I would recommend the perusal of a simple unpretending novel by the Revd. Lal Behari Dey, descriptive of peasant life in the Vardamana, or Burdwan district, called "Govinda Samanta, or the History of a Bengal Raiyat," and particularly Chapter XIX, Evenings at Home, and the conclusions of Chapter XXV. These papers might be distributed at the markets and hâts as well as through the village schoolmasters and local dispensaries. The Bengal raiyat, prejudiced as he may be, wedded to old customs as he undoubtedly is, can understand the value of manures, though he may nor appreciate the beauties of a steam-plough.

The fertility of all soils depends on constituents which they usually contain only in small proportions. These constituents are withdrawn from the soil by the growing crops, and with every recurring harvest the ground (unless there be a compensating element at work) must be so much the poorer. The alluvial soil of Bengal is, perhaps, one of the most prolific in the world; but sooner or later the most fertile ground, unless recuperated by natural means, such as the deposit of suspended matters by the overflow of the river, or artificially,

enriched by manure, must show the effects of this repeated drain upon its resources. This decreasing fertility is a most serious consideration, especially in a country where population is not only increasing, but where high prices, caused by diminished production and increased exports, decrease local supplies and enhance the prices of food, thus making it more difficult for the poor to obtain sufficient nourishment; and where the growing fiscal wants of the country lead to constantly increasing taxation. The cause of decreasing fertility of soil may be ascribed to want of a proper rotation of crops, insufficient manuring, and constant cultivation of the same ground, the land never having any rest. The only remedies for this are,—a suitable rotation and liberal use of fertilizers, and of all the manures within reach of the Bengal cultivator, the most valuable, while the most neglected, is human excreta. 'As man is more richly fed than the lower animals, so his fæces are the most valuable as manure;' and when his indebtedness to the soil, which gives him nearly all the necessaries and even luxuries of life, is thus easily repaid, it would be but common honesty on his part, even were it not to his own immediate advantage, to return to the soil that which it so urgently needs, and which is to him not only useless, but a burden and an abomination. One of the greatest practical and scientific farmers of the present day, Mr. J. J. Mechi, says:—"It is the want of will and belief that keeps sewage in our rivers instead of on our land; I call it national suicide. It is not only the duty, but the interest of landowners and tenants to receive and pay for a valuable and effective producer of human and

animal food. I wonder that any one can doubt it, when we know that its application to land very soon increases the crops, raises the rent, and consequently the fee-simple value of the land which receives it. Look at the Craigentinny meadows at Edinburgh in their natural condition, they were a sandy waste, utterly unproductive. Now, since the application of the town sewage, the average letting value for *six months* of the year is at £22-10 per acre by public auction."* In one of the reports of the Department of Agriculture and Commerce, United States of America, I find it stated that, in Brunswick, Maine, "there was but one man in the town who had acquired wealth by farming alone, and that he had accomplished this by using large quantities of nightsoil on his grass lands and cabbage fields." As a fitting conclusion to this part of the subject, I will quote the words of one of the wisest men of whom England can boast—Lord Bacon:

"And of all sorts of thrift for the public good, I would, above all others, commend to your care the encouragement to be given to husbandry and the improvement of land for tillage. There is no such usury as this. The king cannot enlarge the bounds of these islands, which make up his empire, the ocean being the unremovable wall which surrounds them; but he may enlarge and multiply the revenue thereof by this honest and harmless way of good husbandry."

* Mr. Mechi, of Tiptree Hall, Essex, formerly Sheriff of London, and an Alderman of that city, died on Sunday, the 26th December, 1880, whilst these sheets were in the press. He was an enthusiastic and practical agriculturist, and a strong advocate of sewage utilization.

CHAPTER XIV.

"In spite of the magnitude of the Water-works of the Romans, Greeks, and other ancient peoples, the aqueducts, the storage reservoirs, the public baths; and in spite of the lavishness of the supply for public uses and in the houses of the rich, it is probable that there has never been such general and widespread interest as there is to-day in the matter of water-supply as a sanitary necessity, not only to the community as a whole, but to the individuals, no matter how poor, who make up the community."—*Prof. Nichols.*

The want of wholesome water is without doubt one of the most serious insanitary conditions of nearly all towns and villages throughout the country, and it is aggravated by the general carelessness of the lower orders who take little heed of what they drink or cook with, and who are apt to resort to the nearest waterhole or stagnant pond rather than go any distance for water of better quality, even where it is to be found. Dr. Buchanan, in his "Journey through Mysore," remarks, "that the unwholesomeness of the water in many places is to be attributed in part to the common nastiness of the Hindus who wash their clothes, bodies, and cattle in the very tanks and wells from which they drink."

To whatever cause we may attribute the change, there is ample evidence throughout the country that the people are much more careless of their drinking-water supplies in these days than formerly. The fine old tanks sur-

rounded with raised embankments and with fine substantial masonry ghats that still exist, though generally in a state of decay, are proofs of this state of things; and there can be little doubt that this depreciation in the quality of the water-supply, and this careless use of impure water, accounts in a great measure for the prevalence of cholera and bowel complaints throughout Bengal.

The sources from which the people obtain water for drinking and domestic purposes are rivers, tanks, jheels, and wells.

In purely rural tracts it may be that there is often nothing more hurtful in the water than vegetable matter and animal organisms, which, though possibly hurtful, can hardly with justice be called impurities, inasmuch as they are the natural accompaniments of all natural waters. No natural water is chemically pure, and to obtain a public watersupply, perfectly free from organic and inorganic matters, is an impossibility. "Perfectly pure water," says Dr. Kanailal Dé, "is hardly to be found."

But to any one who is familiar with the country and the habits of the people, it will be plain that other sources of pollution are but too numerous even in strictly rural tracts. The people habitually defæcate on the slopes and margins of the tanks, and after relieving nature, they commonly cleanse themselves in the water. Men, women, and children bathe, and in bathing urinate in the tank; they wash their clothes and domestic utensils; cattle are driven down to drink, or they stray down to the water and cool themselves by immersion, and micturate and defæcate in the water.

When the river is far distant, the Hindu dead are cre-

mated on the margins of the tanks, and their rags and pillows left to rot; and in many parts of Bengal the Mahomedan dead are buried close to the water—in the rains the earth becomes saturated; the hollow grave fills with water, which laden with organic matter and the products of putrefaction, percolates or overflows into the tank. A late Sanitary Commissioner of Bengal informed me, whilst these pages were being written, that he had personally counted on the margin of one tank in the Burdwan district the recent graves of thirty Mahomedans who had died from the cholera epidemic then raging. That they were *all* within nine feet of the water, the closest being two feet only from the water's edge.

River water is similarly polluted, though in this case from its rapid motion, greater volume, and more complete oxidation, the evil is not so great as in the case of the water of tanks or reservoirs. In the Dacca district pauper corpses are sunk in the river near the public ghats, with bamboo stakes driven through the abdomen into the bed of the stream, the people having no scruple in drawing water from their vicinity.—(Dr. Wise's Report.)

Within towns and the more thickly populated suburbs, however, the sources of contamination are much more numerous and much more hurtful, and it would be almost an impossibility to preserve the water of any ordinary tank or pond from pollution of a most dangerous character. As noticed in the Chapter on Drainage, tanks are too often made the catch-water basins of all the surrounding drainage, the foulest portion settling in the tank as only the spill water runs off the surface. They are universally used for washing and bathing in, and

where the population is dense, the amount of animal pollution thus contributed may be understood, the more so that it is in evidence that natives invariably urinate in the water whilst bathing.

People ease themselves on the banks, and Dr. Wise remarks of Dacca, that "cesspools are found on banks of tanks, and within a few feet of wells; and privies, if made at all, are constructed near a tank into which the first rain carries the sewage." In the suburbs of Calcutta privies were not unfrequently to be found *overhanging* tanks or situated along the course of wet ditches communicating with them.

Cowhouses are constantly located close to them, the decomposing dung and urine finding their way freely into the water. They are thus subject to defilement from both surface impurities and subsoil percolation. We have the authority of the present Surgeon-General of Bengal for the statement that "many of the tanks in Calcutta were filthy, stagnant pools of sewage," the water from which "was found to be, on analysis, a liquid occupying an intermediate place between urine and liquid sewage." Yet we will find people bathing in such filthy pools, washing and rinsing their mouths, cleaning their cooking vessels, and washing rice and vegetables in the foul liquid, if not actually drinking it.

Mr. Alexander Pedler, F.I.C., F.C.S., London and Berlin, has lately published a pamphlet on "The Past and Present Watersupplies of Calcutta," in which he gives the results of analysis of two hundred samples of water taken from different tanks throughout the town and suburbs.

Mr. Pedler says:—"Taking the results obtained by the

Total Ammonia Test, and judged by the standards which have been put forward by Professor Wanklyn, and the additional somewhat rough ones suggested by myself, it will be seen, as might be expected, that no single tank or well water was of extraordinary organic purity, and that there were only seven tank-waters included under the head of "safe" waters, five of which were from tanks on the *maidan*. Of *dirty* waters there were twenty-six out of the two hundred, or 13 per cent. Of waters considerably contaminated with sewage matter, sixty-four, or 32 per cent. Of *dilute sewages*, there were thirty-two, or 16 per cent., and of *real genuine sewages*, seventy-one were found, or 35½ per cent., that is rather more than one-third of the whole number." "I have no wish to enlarge to any extent on this decidedly nauseous topic, but perhaps the most striking condemnation of the well and tank-waters of Calcutta, and which will appeal to every inhabitant, whether scientific or otherwise, is to say, that a good average quality of Calcutta tank or shallow well-water may be made by mixing six parts of our present hydrant water with from one to two parts of the *most* concentrated Calcutta sewage. This artificial tank or well water will be of about the average composition. It will also be, so far as can be judged, equally healthy for potable and domestic purposes, and as for its taste, odour, etc., it will probably be rather superior to the general run of Calcutta tank and well-waters."

Can any testimony be stronger than this? I opine not; and we may take the tanks and wells of Calcutta to be no worse than the average of tanks and wells situated in any populous native town.

It is difficult to account for this carelessness in such

an important particular on the part of a people whose daily life is so strongly tinctured with ceremonial observances; and who are theoretically so careful to avoid contamination and impurity in their food and persons, and especially as the defilement of tank-water in the manner above described is such a distinct breach of the injunctions of the Hindu Shastras. Dr. Kanailal Dé in an address delivered at the Third Anniversary of the Bengal Branch of the British Medical Association, said: "Tank water, or water from artificial reservoirs, is not pure or holy in the meaning of the shastras, and is, therefore, not usable in religious rites or ceremonies. It may be used for drinking and other domestic purposes where 'Gunga' water is not available; but the greatest strictness is enjoined by the shastras for keeping it clear of all impurities. Menu says, a man should not cast into such waters either urine, or ordure, or saliva, or cloth or any other things soiled with impurity, nor blood, nor any other kinds of poison."

We can, therefore, only ascribe this general carelessness on the part of the people to a blind mistaken religious belief in the innate purity and undefilability of all large bodies of water, (but which really only pertains to Gunga, or Ganges water,) and to heedlessness and fatalism. Careless as the lower orders of the people, especially the residents of towns, are of the sources from which they draw their water, there are no greater connoisseurs in regard to the various qualities and excellencies of potable waters than the Bengalis, as is illustrated by the following classification of the distinctive terms in common use by the natives of Bengal, quoted by Dr. Bholanath Bose, in his Report on Fur-

reedpore. (Sanitary Commissioner's Report, 1868.) The various qualities and classes of water are thus described:

Sroth jol, running or stream water. Buddho jol, stagnant water. Photick jol, perfectly clean water. Ghola jol, turbid or muddy water. Moyala jol, dirty water. Shaph jol, transparent or clear water. Nona jol, salt or brackish water. Meetha jol, sweet fresh water. Bharree jol, heavy water. Hulkee jol, light water. Gobbeer jol, deep water. Solpho jol, shallow water. Buddh jol, bad water. Bhallow jol, good water. Ghonno jol, thick water. Patla jol, thin water. Kadda jol, muddy water. Pocha jol, putrid water. Shayala jol, water full of weed. Panna jol, water covered with panna (algœ). Boda jol, stagnant water, with a peculiar disagreeable styptic taste. Sonda jol, fœtid water.

We may take it as an incontrovertible fact that the conservation of small ponds or tanks in populous neighbourhoods is an impossibility, so far as keeping their water in a fit state for drinking purposes is concerned; much may, however, be done to keep such tanks from being a source of actual nuisance.

All tanks intended for public use should be railed in, to prevent cattle from straying into them; the bank should be raised to prevent surface impurities from washing into them, and all cesspools, privies, and foul cutcha drains or other receptacles for filth, sewage, house drainage, or other offensive matter, within a radius of at least fifty feet, should be strictly prohibited.

The local authority in Bengal has power in the latter respect under section 246, Act V of 1876.

That fertile cause of pollution, the use of the tanks by *dhobies* or washermen, should never be permitted,

nor the steeping of green bamboos to fit them for building purposes, or the steeping and rotting of jute, flax, or other plants for the purpose of separating their fibre.

In towns, where there is any system of nightsoil removal, careful supervision is necessary to prevent *haris* or nightmen from washing their tubs and brooms—a whole tank may not only be polluted, but infected with enteric fever or cholera germs from such a cause.

The above remarks refer only to such tanks as are set apart for bathing and domestic purposes other than drinking or cooking; and notices should be placed at the ghats warning people against drinking the water.

Drinking tanks require much more careful watching, as well as more thorough arrangements, both of construction in the first instance and means of conservation.

To secure good water in a drinking tank, a large area is required both for storage and to serve as a catch-water area. Where practicable, therefore, the water surface should not be less than three biggahs, with a catch-water area surrounding it of equal extent.

No water should be permitted to enter the tank except the direct rainfall over the conserved area supplemented by wells in the bottom. It might perhaps be doubted whether a sufficient supply could be obtained from these sources alone, but there need be no fears on this head.

I will give as an example the instance of a tank constructed near Calcutta in 1875, and which will illustrate the possibility of thus securing a sufficient supply better than mere theories. The site acquired for this tank was nearly seven biggahs in extent, and was a compact square of low land, about six feet below the

level of the surrounding lands, and the adjacent public road. Of this area six biggahs was marked out for the tank and catch-water surface. The tank or reservoir was then excavated to a total depth of twenty-seven feet with a surface area of three biggahs and three and-a-half cottahs. The banks were formed with a slope of two to one, with a four feet berm at eighteen feet; where the footings of the ghats were laid. The remaining land was raised several feet above the surrounding level, with a gentle slope from the edge of the tank outwards to an artificial stone channel on all sides of the conserved area, the water falling over this area being caught by the stone channel and led by masonry shoots at the corners into the reservoir; by this means erosion and guttering of the banks is effectually prevented. The supply of water derived from the direct rainfall is supplemented to some extent by four deep wells in the bottom of the reservoir, which is calculated to hold over four millions of gallons of water. The reservoir was planned on the following calculation: The rainfall in Bengal for the ten years previous to construction had varied from 45·55 inches to 93·31 inches, the average, therefore, was taken at 70 inches per annum. It had been ascertained by experiment that, with a rainfall of 70 inches, the amount of water falling over a measured area of 1,200 square feet amounted to 43,628 gallons. Taking the catch-water area, therefore, to be six biggahs, or 86,400 square feet, the amount of water falling over it with the same rainfall would amount to nearly 3½ millions: we may assume the loss by evaporation and absorption to be counterbalanced by the springs and wells, and as the entire supply is not consumed, the rainfall is ample

to maintain the water level. Although we have had, during the past year, the shortest rainfall known for some twenty years, this reservoir has never had less than seventeen feet of water in it at its lowest, and its water is in use by a large neighbouring population.

In constructing tanks due heed must be had to the soil and to the surroundings. A tank, wholly or partly excavated in what is termed made-up ground, that is, originally low land raised in the course of years by refuse deposits, will hardly ever yield good water, and the subsoil of nearly all our old Indian towns is so fouled by the soakage of the sewage or filth of generations, that great care is necessary in selecting a site. If the soil be loose and sandy, and there be a number of filthy ponds or cesspools in the vicinity, there will always be the danger of sewage percolation from them into the new excavation. This may, of course, be prevented to a great extent by well puddling the bottom and sides of the reservoir, or by the use of a puddle core in the embankment; but this adds greatly to the cost of the work, is not always easily effected, and from the slipping of the banks or the disturbance of the puddle coating is not always effectual in preventing filtration. A new tank, therefore, should always be dug, where possible, in fresh new ground, and all cesspools and filthy ponds in the vicinity should be emptied, cleansed, and filled up with earth. This can generally be easily effected whilst the excavation is in progress, and the spoil earth is available.

Where a tank is to be excavated near a river and in sandy soil, advantage may sometimes be taken of the tendency to filtration to secure a constant supply of

water partially filtered, and therefore cleared of the silt and mud, held in suspension by the river water.

A rather curious instance of this exists in a fine large reservoir constructed by me, some years ago, in Garden Reach. There had existed, for many years, at the back of the Government Dockyard premises, a very extensive jheel or swamp, and which, as its name, *the Adhygunga*, implies, was, in former years, a portion of the original bed of the Ganges. At what period it was cut off from the river I do not know; but a good many years ago, when the Dockyard premises were enlarged, the old Garden Reach road was diverted and carried across a portion of the swamp, which had been, in the course of years, filled up by the deposit of sand from the docks, mixed with the cinders and slag from the furnaces and cupolas. The swamp was long an eye-sore and a source of malaria and sickness to this part of the suburbs. In 1875, the Government offered the site, some fifteen biggahs, to the Municipality free, on condition, that a tank should be formed in one portion of the ground, and the rest of the swamp raised and reclaimed. The work was accordingly taken in hand, a portion of the native village adjoining purchased and removed, and a fine rectangular reservoir, with a water surface of nearly six biggahs surrounded by walks, grass, and ornamental shrubs, now occupies the site of the old, unsightly, and pestiferous swamp. Owing to the nature of the soil, a wet sand, it was found impossible to get deeper down with the excavation than seventeen feet, the water below this depth rising fast in the cuttings. Whilst making the excavation, undeniable proof was discovered of the swamp having formed in

bygone days a portion of a river bed, for, at a depth of ten feet below the surface of the bed of the jheel, several portions of sunken boats came to light, and in one spot an entire boat, measuring some thirty feet in length, was disinterred, containing, besides the remains of firewood, rice-bags, earthen utensils, &c., the complete skeleton of a man, portions of two other human skeletons being found underneath and close to the boat.

At one corner of the tank, a most persistent spring of clear water interfered greatly with the work, the water filling up the cuttings as fast as it could be baled out; and, on investigating the cause, the spring was traced back to the bed of cinders and slag underlying the Garden Reach road. Adjoining this is a large settling tank for the river water used for the foundry boilers, and which is pumped daily from the river, the water passing through the thick bed of cinder, slag, and sand, is, therefore, effectually filtered. A pipe culvert was laid to conduct this water into a settling well, from whence it passes into the reservoir through an overflow pipe. There is thus not only a constant accession of fresh filtered water into the reservoir, but a continual, though imperceptible, current through it, which assists in keeping the water clear and fresh. The supply is so constant, that, in the hottest and driest seasons, the water level only sinks from two to three feet.

The two examples given will serve to show what can be done to improve a tank water-supply and at a comparatively small cost, the two tanks mentioned having been completed, inclusive of purchase of land, construction of ghats, drains, railings, and turnstiles, for something less than Rs. 8,000.

In all tanks or reservoirs, water plants and fish in moderate quantities are a necessity: the former exert a distinct chemical influence on the water, while the latter not only prevent overgrowth of vegetable matter, but consume a large quantity of insects, crustaceæ, and organic matter.

That well-known Indian Chemist, Dr. David Waldie, of Cossipore, says:—"Some of the best tanks, General's tank more particularly, are probably equal to the river water in purity at some seasons, and superior to it at others. Tank water deteriorates in the hot season from putrefactive fermentation, the river water proper improves from oxidation, but near Calcutta deteriorates from sewage and tidal water. Tank water improves during the rains by dilution with rain water, *and the animal and vegetable life in it preserves the proper balance, removes decaying matters, and prevents putrefaction to any great extent;* at least this is the case in good tanks. *General's tank seems a well kept aquarium: it abounds in animal life.*"—(Asiatic Society's Journal.)

Dr. Wilson says,—"the purifying process is aided to some extent by the presence of fresh water plants;" and again, "among other purifying agents may be mentioned the effects of plants and fish." In store reservoirs, the presence of a moderate quantity of living plants exerts a decidedly purifying influence, while the destruction of fish has been followed by an excessive multiplication of the small crustacean animals on which the fish had lived, thereby rendering the water nauseous and impure. The remedy was found in re-stocking the reservoir with fish (Rankine).—(Wilson's Hygiene.)

Of the water-plants best suited for preservation of

tank water, the following are best known to me: Nymphæa rubra (Bengali, rukta kumbula), which has long india-rubber like stems, varying with the depth of water and deep red or blood-colored flowers, hence the Bengali name; Vallisneria alternifolia (Bengali, rusna jhanj), stems rising with the water; Vallisneria vertecellata (Bengali, dhap or daam); and Vallisneria octandra (Bengali, patta sewala), the water-plant used by the Jessore sugar-refiners to cleanse their raw sugars. Westland, in his account of Jessore, gives the name of the weed as syala: and, according to Roxburgh, it is a grass-like plant, growing in standing shallow water.

The beauty of the Nelumbium speciosum, water bean (Bengali, pudma), would seem to make it a desirable plant for reservoirs; but it should, nevertheless, be avoided, as it tends to accumulate mud, and injures the water.

In addition to the higher order of plants which I have enumerated above, there are a number of harmless confervoid growths belonging to the class of cryptogamous or non-flowering plants, known as algæ, which flourish in water, and generally in tanks or ponds, where they float about in masses, sometimes covering the whole surface with a deceptive carpet of verdure. By their growth they do no harm to the water, but rather act as a preservative, for when this green veil is swept aside, the water beneath will generally be found far clearer than in tanks free from weeds. I believe the crusade against "pannas," as they are universally called, to be a decided mistake; the danger lies, as in the case of jungle clearance, in the plants being gathered from the surface or lodged on the banks as the water level sinks in the tanks, and there allowed to die and decay.

Professor Nichols considers that there is no reason to believe that the presence of these minute algæ gives an unwholesome character to the water. They are not, in his opinion, a sign of impurity, as they grow in ponds which are far removed from all sources of contamination. —(*Buck, I.*, 238).

All water-plants, stranded on the banks as the water sinks in the tanks, should be carefully cleared away and not allowed to rot.

Of the fish best suited for stocking tanks, the kátla, ruho or rooi, kalaboas, mirgal, all of the carp family (Cyprinidæ), are the most desirable.

The young fry of these fishes are largely sold during the months of July and August by fishermen who net them on the shallows in the Hooghly and in the Damoodur and other tributaries. They are carried about for sale in large flat shallow vessels of black earthenware filled with water, and kept constantly in motion.

Wells, as sources of supply of drinking-water, are not in favor with the Hindus of Lower Bengal, but there may be localities where they are the only means of procuring a supply. Wells are very subject to sewage contamination, and often contain nitrites and nitrates of ammonia, lime organic matter, and, where situated near graveyards, fatty acids.

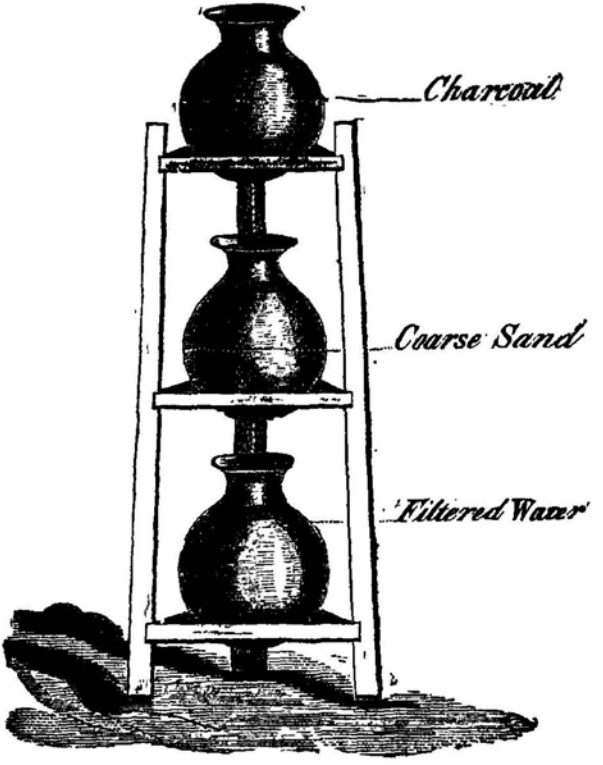
Where a well exists in fouled ground, the only course is, to abandon it and dig a new well in clean ground, and away from all possible source of pollution; the subsoil water and all impure percolation must be cut off by casing the well to a depth of 10 feet from the ground level with brick-work, with cement joints, concrete, or, what is cheaper and better than all, with *puddle.*

In constructing a well with puddle, the common baked earthen well-rings or "tikras" must be used, and the excavation being made about three feet larger in diameter than the well-rings, the puddle stuff must be rammed firmly down and well worked.

Puddle to be impervious must be carefully and thoroughly worked, as well worked as the clay for a well moulded brick. Surface alluvial soil will not do for the purpose; a light loam or clay, with a slight admixture of coarse sand or fine gravel, is the best. This must be well worked with sufficient water, and trodden up by the coolies' feet to a stiff tenacious mass: it must then be packed in behind the rings and thoroughly worked or punned down, taking care not to crack or break the rings in doing so. The well tube should be carried up two feet above the ground level, and a protecting ring of brickwork built round it, and the surface sloped and paved, or concreted, to prevent waste water from draining back into the well; the mouth of the well should be covered over, and either a pump fixed over it or a windlass with a bucket and chain; the only objection to the latter is, that it is apt to swing against the sides and break the earthenware rings, which are somewhat fragile.

There can be no doubt that, if the people could be induced to boil and filter the water used by them, that many dangerous waters might be thus used with comparative safety; but this cannot be expected, the very cost of fuel would prevent the poorer classes from taking this precaution; nor is it at all probable that they could, to any extent, be brought to filter their drinking water, although the materials for constructing a most efficient filter is to their hand, and at an outlay of but a few pice

—a rough wooden stand, three ordinary porous earthenware *culshis* or jars, a small quantity of charcoal or sand being all that is necessary.



The local authority might, however, greatly improve the supply from public tanks by constructing filtering draw-wells in connexion with the tanks from which the

water should be drawn by a pump or iron bucket and chain, after being filtered through gravel, coarse sand, and charcoal.

Good drinking-water should possess the following characteristics: it should be tasteless, odorless, clear, transparent, and without any color, or as the Spaniards say *ni sabor, olor, ni color.* It should be cool and well aerated, and free from deposit and living organisms. A drinking-water may contain a greater or less amount of dissolved mineral matter without detracting from either its wholesomeness or palatability. A perfectly pure water, such as is obtainable only by distillation, is, it is well known, most unpalatable, owing to its entire want of aeration and the absence of the dissolved gases and mineral salts which occur to a greater or less extent in all natural waters. The water obtained for ship's use by distillation of the sea-water in Normandy's condensers, is, until aerated by artificial means, not only unpalatable, but by some authorities supposed to be indigestible. One of the pleasantest and most wholesome waters is rain or cloud water: it is in fact the purest of all except distilled water. When received on a clean collecting surface, and carefully preserved from contamination, it is pure, soft, and highly aerated, possesses high solvent powers, and hence is valuable for cooking and in chemical operations. Those who have become accustomed to drink rain-water from clean cisterns or reservoirs, prefer it to deep well-water, and claim that it is a better thirst-quencher, as well as a restorer and preserver of health and a preventive of many diseases. An American writer, in an article in the United States Government Reports, states, that "it is a well-established

fact among intelligent medicalmen, that the stomach and bowels are far less liable to derangement and disease, and to attacks of epidemics under the uniform use of rain-water than of hard-water." This is confirmed by numerous medical and scientific reports in different countries.

"It has been clearly ascertained both in Paris and elsewhere, that rain-water is a prophylactic (antidote) to cholera: and that the disease was not proved an epidemic in any city where rain-water was exclusively used." Dr. Hobbs of Memphis states,—"By the exclusive use of cistern-water (*i.e.*, rain-water), cholera will speedily disappear and not return;" and Dr. Lea, of Cincinnati, declares,—"That it is a verified fact, which will stand the strictest investigation, that the exclusive using of rain-water for all purposes of drinking, cooking, and bathing, instead of hard or well-water, is a sure preventive of cholera and bowel complaints; and that no town or city supplied exclusively with rain-water ever suffers seriously from epidemic cholera." The late Dr. Parkes, of Netley, also gives valuable testimony in favor of the use of rain-water in preference to spring or well water. He says,—"The greatest benefits have resulted in many cases (especially in the West Indian Islands) from the use of rain, instead of spring or well water, which is often largely impregnated with earthy salts." Of course, these opinions hold good only in regard to rain-water as received from the clouds and so collected and stored as to prevent its being contaminated by organic and other impurities.

Davis mentions as a curious fact in reference to the West Indies, that "ships' crews, when ordered to Tortola, were 'invariably seized with fluxes,' which were caused by the water. But the inhabitants, who used tank,

i.e., rain water, were free, and so well was this known that, when any resident at Tortola was invited to dinner on board a man-of-war, it was no unusual thing for him to carry his drinking-water with him."

Not many years ago before the present filtered water supply was provided for the city of Calcutta, nearly all the old residents used to store the rain-water collected from the flat terraced roofs of their houses in large earthen jars, or jallahs, the care of which was one of the principal duties of the now-extinct, but formerly important domestic official, the *abdar* or waterman; and nearly every house had a special abdarkhana or water-house set apart for the keeping of the drinking-water jars. There were indeed several old European Calcutta residents alive up to a very recent date, if they are not so still, who, having for many years been accustomed to drink nothing but rain-water, continued to do so even after the introduction of the filtered public supply; and an advertisement of about seventy years ago shows, that the aerated soda-water manufacturers of that day held out as an inducement to consumers that their soda-water was prepared from *rain-water* only.

Many large cities in the south of Europe are entirely supplied with rain-water, such as Constantinople, Venice, Cadiz, and other places. In the latter city the roofs have a self-acting tilt-trough, which throws off the first rainfall with the impurities washed from the roof, before allowing the water to run into the reservoir. The Spaniards, who have a proverb for every thing and every occasion, say of rain-water, that it neither makes men sick, nor indebted, nor women widows: "Agua que no enferma, no adeuda, no enviuda."

CHAPTER XV.

"No tree in all the grove but has its charms."—*Cowper.*

"States, societies, and individuals have encouraged by bounties the planting of trees with sufficient success, at least to excite thought and stimulate effort upon the subject of practical arboriculture."—*American State Reports.*

There are several objects to be attained by a systematic planting of trees on the road sides, the public squares, and on waste and unoccupied lands, recently reclaimed ground, and old and unused burial-grounds.

First, we have in view the beautifying of the town, the provision of grateful shade, and the diffusion of sweet scents. *Secondly*, the purification of the atmosphere by the absorption by plant-life of carbonic acid and ammonia, and the diffusion of oxygen and ozone. *Thirdly*, the drying of the subsoil, and the withdrawing from it, by the same powerful agency, of the elements of decomposition. *Fourthly*, the preservation of the road surfaces. *Fifthly*, the equalization of the rainfall. *Sixthly*, the interception of malarious air currents by belts of trees; and *seventhly*, the production of valuable and useful timber and refreshing or nourishing fruits.

The *first* of these objects must be patent to every one. What can be more dreary and depressing than a town destitute of trees and vegetation, and what visitor to

Calcutta in the months of March, April, and May has not been struck with the wondrous blaze of color exhibited by the simul or cotton tree, and the Poinciana regias glowing above the soft refreshing verdure of the numberless foliage trees with which the town and its surroundings abounds. What traveller has not blessed the grateful shade of the umbrageous banyan, the bokal or the tamarind; and what manner of man is he who has not scented up with delight the cool evening air laden with the delicate perfume of the magnolia, the har singha (Nyctanthes arbortristis) and the jasmine, or the more potent honey-like fragrance of the champa and the kuddum.

Of the *second* object sufficient explanation has been given in the chapter on Rank Vegetation. Of the *third*, the explanation is easy. Plants transpire freely when they have a moist soil to draw water from, and a dry atmosphere around them. For example, it has been calculated that a beegah of grass will part with moisture to the atmosphere at the rate of 4,266 pints per day. A single sun-flower plant transpires about one pint of water daily, nearly all this water being drunk up from the soil by the roots, the speed of the circulation being nearly twenty-four inches per hour. Experiments recently made show, that "plants in a saturated atmosphere transpire most when exposed to the sun, and that in the shade transpiration ceases when the atmosphere is loaded with watery vapour." Trees also affect the drainage of the soil by mechanical action, the roots permeate the subsoil and open up numberless drainage channels through otherwise impervious strata. In fact, they perform the office of draining in a manner analo-

gous to that artificially practised in parts of Holland and the British Islands. This method consists in driving down deeply into the soil several hundred stakes to the acre; the water filters down along the stakes, and in some cases as favorable results are said to have been obtained by this means as by horizontal drains (d'Hericourt, Annales Forestieres, 1857). It will be found that the earth is always much dryer near the roots of trees than elsewhere; and it is an established fact that cutting down woods and forests has, in many known instances, converted considerable tracts of well-drained land into swamps and marshes.

The preservation of the road surfaces is effected by shielding them from the baking torrid heat of the summer sun and retarding evaporation from their surfaces. The equalization of rainfall is, undoubtedly, affected by the planting or denuding of a district of trees. On this head all good authorities are at one. Humbolt, Herschell, Bousingault, and others are agreed that the destruction of forests is followed by diminished and less equable rainfall; and it is known that in forest regions the ground covered with trees receives more water than the uncovered ground of regions with little or no wood. The rainfall is also greater over forests when the trees are in full foliage. The late Pasha Mehemet Alli made extensive plantations in Lower Egypt with a view to increase the rainfall. Previous to this there was hardly any rain, often none for more than a twelve-month; now that the forests have grown up, the annual average is said to be thirty days rain in the year. On the contrary, it is asserted, that, in Upper Egypt, the rains, which a century ago were abundant, have ceased since the Arabs cut down

the trees along the valley of the Nile toward Lybia and Nubia. Some years ago, Saint Helena was almost denuded of timber, the consequence being a very great diminution of the rainfall, which, when it did fall, came down in a deluge. Since tree-planting has been steadily progressed with, the rainfall has again become regular and equable.

It is a well-known fact that belts of trees, interposed between inhabited localities and marshes or swamps or surrounding burial-grounds and cemeteries, intercept the noxious exhalations and malarious air currents when the wind blows from their direction. Monsieur Regaud de l'Isle, writing about the malaria of the Campagna di Roma, says: "Various obstacles form barriers which miasmata cannot pass; the interposition of a forest may preserve us in a variety of circumstances from the pernicious effects of air currents charged with deleterious miasmata. Upon Mount Argentel, above the village of San Stephano, there is a convent, which has lost all its reputation for salubrity which it once enjoyed, since the lofty trees by which it was surrounded have been cut down. In consequence of the felling of the woods before Asteria, near the Pontine marshes, Veletri was visited for three successive years by diseases unknown before." Volney states a remarkable fact relative to this subject: Beyrout, formerly very unhealthy, quite ceased to be so since the planting of a wood of fir trees by the Emir Fuqr-ed-din, about a league below the town. Dr. Ferguson, in a paper on Marsh Poison, in the Medical Chirurgical Review (1821), remarks, that "the town of New Amsterdam in Berbice is situated within short musket-shot to leeward of a most offensive

swamp, in the direct track of a strong trade-wind that blows night and day. Yet it brings no fevers, though every one is well aware that it would be almost certain death for a European to sleep, or even to remain, after nightfall, under the shade of the lofty trees that cover the marsh at so short a distance. All too are equally aware that to cut down the trees would certainly be productive of pestilence to the town."

These are somewhat antiquated authorities, but they are none the less sound; and the views enunciated by them as to the protective influence of belts of plantation are still received by sanitarians without question. Dr. Parkes, of Netley, says,—"The protective influence of a belt of trees against malaria is most striking;" and Dr. Adam advocates the surrounding of burial-grounds with trees to act as a barrier to the escape of miasmata.

Whether the action is purely mechanical, or whether, as some suppose, trees possess the power of neutralizing malarial poison by some chemical agency, has not been determined.

Eminent medical men have of late years advocated the planting of belts of trees between the great swamps known as the Salt Lakes lying to the east of Calcutta and the suburbs, and we can hardly doubt that the result would be beneficial. Unfortunately, in the vegetable as in the animal kingdom, beauty does not always go hand-in-hand with utility and strength; and many of our most ornamental flowering trees are of little or no use either as fruit or timber producers, and in proportion to their rapidity of growth and the fragility of their wood, they are liable to quick decay and

damage by high winds and the cyclonic disturbance to which the weather in Bengal is so subject.

First and foremost amongst the purely ornamental trees we may note the Poinciana regia, or Flamboyant as the French call it, which flowers in April and May, and is then a gorgeous blaze of scarlet and yellow; and after flowering is still a handsome object for some months of the year from its bright green feathery foliage. It bears seed abundantly in some seasons, but is somewhat difficult to raise, and is extremely fragile, when it grows large enough, to oppose resistance to heavy winds.

The Colvillea racemosa, a tree much resembling the last in foliage, is a stately object, bearing high aloft in September its noble drooping racemes of orange-colored flowers, but remains bare of foliage for a considerable part of the year.

The Cassia fistula (or amultâs) presents a truly magnificent mass of pendulous laburnum like yellow blossoms in all May and June, succeeded by long black cylindrical seed pods, as round as a ruler, and from one and-a-half to two feet long.

The Cassia marginata is a somewhat small tree but occupying considerable space from its widespreading habit. Blossoms profusely, principally in the rains, but also through the hot weather, with numerous rose-colored flowers, and is a very ornamental object, better suited for a shrubbery or open ground than for a roadside.

Lagerstræmia regina (jarool), a handsome tree, bearing a profusion of rose-colored or purple blossoms (*see* also Timber Trees).

The Cassia Javanica is a handsome forest tree; a mass

of beautiful pink blossom in April and May, and bearing large heavy rugose bean pods.

All these trees, however, are of little beauty, except when in flower, and give little shade.

The following trees are all suited for road-side planting being handsome, hardy, and giving good shade:

The Dellenia speciosa (chaltâ).—A hardy handsome tree, with large-ribbed chestnut-like leaves, noble white scented flowers, blossoming in July, succeeded by large green sepalous apple-like fruits.

The Magnolia pterocarpa, a handsome tree, with large smooth glossy leaves, and globular white fragrant flowers; blossoming in April.

The Nauclea cadamba (or kuddum), a fine shady forest tree, bearing in July a profusion of soft buff-colored sweet-scented flowers, perfectly globular in shape and of the size of a tennis ball—a charming road-side tree.

Swietenia mahogani, or mahogany tree, is an exceedingly handsome and valuable timber tree, but of slow growth.

The Melia sempervirens (or bukayûn), a rather handsome tree, with ash-like foliage and elegant lilac-scented flowers.

The Jonesia asôca (asôc), one of the most gorgeous and beautiful objects of the vegetable world when in full bloom, with its large compact trusses of orange and scarlet. Flowers in February and March, and again occasionally in June or July, but not to the same extent. Gives a thick heavy shade, and when out of blossom is still ornamental from the graceful droop of its foliage and the numerous pendant, India-rubber like leaflets, of various shades of purple and bronze.

The Mimusops elengi (or bokul), a very fine timber tree, bearing, in March and up to July, small spurrowel-shaped fragrant flowers, a great favorite with the Bengalis, and deservedly so. There is no finer object than a handsome well-grown avenue of bokul trees, such as one existed a few years ago on the western bank of Tolly's Nullah, near Tallygunj, as an approach to the handsome group of temples, or *Thakoorbattee*, erected by the Munduls of Bhowally, and dedicated to the God Radhakrishna. The owners having become involved in debt, this noble avenue, the finest I have ever seen, was ruthlessly cut down and sold for timber by a grasping decree-holder.

Kigelia pinnata, a large somewhat coarse-foliaged tree, with very remarkable rope-like woody flower stems which hang from the branches to a length of ten feet till they nearly touch the ground, and bear a succession of handsome, deep *sang-de-bœuf* colored flowers, which give forth at night a somewhat unpleasant smell.

The Grevilla robusta, a very beautiful pyramidal tree, with dense fern-like foliage.

The Ficus elastica (India-rubber tree), Ficus Indica (bâr), and Ficus religiosa (pipal), are all useful shade-trees for road-sides.

The Casuarina muricata and the Uvaria longifolia, or *Debdâru*, are too well known to need description.

Of the fruit trees the following may be enumerated:

The Mangifera Indica, or mango (ám); the Artocarpus integrifolius, jack-fruit (kûntal); the Tamarindus Indica, tamarind (tentool); the Adansonia digitata (Baobab), monkey bread fruit or bilaetee tentool; the Dellenia speciosa (châlta); the Diosperos kaki (bilaetee gab); the

Jambosa vulgaris, roseapple (or gûlab jam); the Jambosa alba, starapple (or jumrool); the Terminalia catappa, Indian almond (or dêsee badam).

The following are amongst the most useful timber trees:—

Melia azad (Neem)—A hardy and quick-growing tree, much prized by the natives for its medicinal qualities. Yields an useful fragrant wood for household purposes, the heart wood much resembling mahogany.

Tectona grandis (Sagoon, teak)—A large forest tree, yielding a valuable wood, but of very slow growth.

Acacia sirisa (Siriss)—A rapidly growing tree with a coarse-grained timber of little value; used principally for box planks.

Nuchelia champacca (Champa, Sampangi)—A small tree, prized by the natives of Bengal for its large narrow-petalled flowers of a dull yellow color and delicious fragrance, and which are used in religious ceremonies. The wood is of a rich brown color, close-grained, finely mottled, takes a fine polish, and makes beautiful furniture.

Acacia, catechu (Shah)—A large tree, with bipinnate foliage, yields the *cutch* of commerce. Timber considered more durable than teak; used for posts, rafters, spear-shafts, &c.

Dalbergia sissoo (Sisu or Sissoo)—A handsome and useful timber, strong and durable, with a close compact grain; suitable for all kinds of joiner's and carpenter's work.

Inga dulcis, a very fast-growing tree, with a very tough, hard, heavy, close-grained wood, very like ash.

Lagerstrœmia regina (Jarool)—A splendid tree, with

rich rose-colored, or occasionally purple, blossoms. The timber is most useful for all purposes, house-building, planks, scantlings, boat-building, &c.

Erythrina Indica (Pahta Mundur *Kashi*)—A moderate sized tree, very common; bears in March clusters of brilliant scarlet flowers, but of no beauty at other times; yields a strong wood, useful for floor or wall-planking, but of no great scantling.

Feronia elephantum (Kuthbêl)—Grows to a good size; good timber, close and even-grained; used for doors and rafters in native houses.

Artocarpus integrifolius (Kuntal, jack)—Yields a handsome wood for furniture-making, also for ghannees or native oil-mills.

Grislea tomentosa (Kardahi, Dharee dhao)—A small tree with drooping branches. A mass of dazzling red when in flower in February and March; wood strong, close-grained, and heavy; useful for posts and tie-beams when procurable of sufficient size; is easily established and a rapid grower.

Ficus guleria (Goolar)—A common, coarse, fast-growing tree, with a coarse grained brittle wood; only useful for one purpose, well-curbs or foundations for steps, as it does not decay under water.

Nauclea cadamba (Kuddum)—Gives a wood of close and even grain, but brittle and wanting in strength.

Swietonia mahagoni (Mahogany)—Too well known to need description.

Bombax heptaphyllum (Simul)—A tree of very rapid growth, bearing a gorgeous crimson flower, succeeded by pods full of silky cotton; the wood is light and coarse, but planks cut from old trees make good boxes.

The following are suitable for planting on waste land and burial-grounds :—

The Dalbergia (Sissoo)—This common tree of the Indian jungles grows fast, and has a capital wood, useful for many purposes.

The Rain tree Guango (Pithecolobium Saman)—A very fast grower; gives splendid shade, and yields a pod with a sweet pulp, which is greedily eaten by cattle, but gives a timber of little value except as fuel. Any of the smaller fruit trees are also suitable, such as the Psidium guajava, guava (pyara or amrood); the Achras sapota, sapota (supattoo); the Zizyphus jujuba (bâer) kool; Zizyphus vulgaris, plum (koolphul); and many others. No plant is more useful in this respect than the Musa sapientum, the plantain (kela), of which there are several good kinds, the best being the champa, chinee-champa, martaban, Daccaé.

The above list is in no way intended to be exhaustive, as I have simply given the names of those trees with which I am myself best acquainted; many others will, doubtless, suggest themselves to the reader.

In planting trees by the sides of roads, a good sized circle or disc of turf should be removed from the spot selected. The earth should then be dug up to a depth of at least two feet, and if of a poor description, fresh earth, or preferably leaf-mould, should be substituted. The young tree planted in the centre of this must be protected by a stout basket from the ravages of cattle and goats, the latter especially are most destructive. Trees must be watered in the dry season, and their enclosure must be kept free from grass. No young plants will flourish if choked with *oolá* or *motu* grasses.

A good deal might be done to encourage the planting and preservation of trees on the road-sides by the adjacent householders, by offering a small premium for each tree planted and preserved in health until it attains a certain height. This practice is followed in some of the States of the North American Union. Hindus also are always ready to plant and water Ficus Indica and Ficus religiosa.