WATER-SUPPLY SYSTEMS IN RURAL AREAS OF INDIA : WEST BENGAL *

Ancient Indian writings contain many references to the supply and preservation of water. For example, in the *Rigveda*, which dates from 4000 B.C., wells are mentioned as means of community water-supply; and in the *Mahabharata* (about 400 B.C.), reference is made to the drawing of subsoil water to ground-level through a pierced hole. In another writing—the *Artha-Śastra* (laws of finance)—it was stated that one well must be provided for every 10 houses. Until not long ago, the construction of wells or the excavation of tanks for community use was considered an act of great piety, and there are still relics of tanks as large as 2,000 feet × 1,000 feet (610 m × 305 m), with a depth of 25 feet (7.5 m), which were donated to the public by the wealthy persons of the locality. Indians considered water a purifying agent, and there were very strict sanitary laws about preventing pollution. In the *Ayurveda* (4000 B.C.) we find the following injunctions : (1) Do not spit into water; (2) Do not pass urine or discharge faeces into water; (3) Do not drop blood into water; (4) Do not throw hair, nails, bones, or ashes into water; (5) Do not dip dirty clothes into water.

At present there are, besides lakes and rivers, three sources of water-supply in existence in rural Bengal. These are (1) surface tanks, (2) surface wells, and (3) tube-wells.

Surface tanks

From primitive times, surface tanks have been a source of water-supply in rural areas. In the past, such tanks were excavated by the villagers themselves, by means of manual labour, until the subsoil water-level was reached. The tanks were filled during the rainy season by the drainage from the catchment-area, and in the dry season formed a source of supply for the local population. Unfortunately, present-day villagers, ignorant as they are of the rules of sanitation known to their forefathers, use tanks for all purposes, such as bathing and washing clothes, which results in the water's becoming contaminated and polluted. The same water is used for cooking and drinking. It is a mystery how people can survive the use of so much contaminated water. The answer is probably that such people develop a certain immunity through its continual use. There are cases of gastro-intestinal disorders, but disease rarely breaks out in the form of an epidemic except in the case of cholera.

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In a well-ordered village community, there are reserve tanks which form a source of water-supply. These tanks have embankments on all sides and are fenced in. The former save the tanks from drainage of the catchment-area, and the latter from contamination by animal or human agencies. Water is drawn from the tank by a hand pump which conveys it outside the fenced area. These reserve tanks are usually constructed at places where subsoil water, at a depth below the first layer of impervious strata, is generally saline. The water from such tanks has been found to be fairly good and cases of sickness are few. The tanks can be excavated with ordinary tools and no skilled labour is required.

Surface wells

In Bengal, there are three different forms of construction for surface wells : (1) with earthen rings, (2) with reinforced-concrete rings, and (3) with masonry.

Earthen-ring wells

This is the oldest type of well in existence in villages. The rings are usually 2½-3 feet (0.8-0.9 m) in diameter, and are manufactured by the village potter along with the earthen vessels used for cooking and other purposes. These rings, made of alluvium clay, are puddled, turned on the potter's-wheel, and afterwards fired in local kilns. Excavation is made to the required diameter, according to the size of the rings, and they are then placed one on top of another, to guard against the slipping of the earth, until the subsoil water-level is reached. The water is then bailed out, further excavation is made, and the rings are placed in position. In this way excavation is carried on to a depth of up to 10 feet (3 m) below the normal subsoil water-level. The average depth of such a well varies from 20 feet to 25 feet (6-7.5 m), and the cost is roughly 150 rupees ($31.50). Such wells are cheap to construct, but it is difficult to excavate beyond a certain depth. The earthen rings are liable to break, and deteriorate very quickly. The joints between the successive rings are not watertight and the well-water is not always bacteriologically pure.

Reinforced-concrete wells

The rings are up to 6 feet (1.8 m) in diameter and 1 foot in depth (0.3 m), and are cast in moulds. As these rings are sufficienthy resistant to soil pressure, it is possible to excavate, without danger, as much as 80 feet (24 m) below ground-level. The joints can be made watertight and the water, if drawn from the subsoil, is fairly satisfactory. A well 4 feet (1.2 m) in diameter serves about 400 persons, and with a depth of 40 feet (12 m) costs 1,200 rupees ($252.00).

Masonry wells

This type of well is the most expensive, but can reach a much greater depth—as much as 90 feet or so (27 m). The well-curb is usually made with hard wood and the cutting-edge is formed with an angle iron. In the beginning, excavation is made to the required diameter, and to as great a depth as possible without the earth's slipping at the sides of the well. The well-curb is placed in this hole and brickwork is constructed over it till the structure reaches 3-4 feet (0.9-1.2 m) above ground-level. Earth is excavated from the inside, and the well gradually sinks from its own weight. Another section of brickwork is added to the top and further excavation is made from inside the well. The work proceeds in this way till the desired depth is reached. It is not uncommon to sink wells in this fashion to a depth of 90-100 feet (27-30 m), especially in areas where the surface is of laterite or other rock, and where the subsoil water-level goes down to 60-70 feet (18-21 m) during the dry season. A parapet wall is built to prevent ground-water from getting into the well, and a platform is constructed around the well for draining away the spill-water. Either a pulley arrangement or a pump is installed over the parapet wall for drawing water. A masonry well 4 feet (1.2 m) in diameter and 40 feet (12 m) deep costs 2,200 rupees ($462.00).

Tube-wells

From over 30 years' experience, it has been found that the best and safest source of water-supply is the tube-well. For its construction a pipe—usually of galvanized wrought-iron—is driven into the earth until water is struck. At the bottom of the pipe a strainer or filter is attached, which admits subsoil water, but prevents the entry of fine sand. During the sinking of the pipe the first impervious layer is passed through and the sandy layer next encountered is selected for the supply of water. This prevents the percolation of contaminating ground-water. In West Bengal, an abundant supply of ground-water is found and once the tube-well is placed in a water-bearing stratum, no difficulty is usually experienced. The water-bearing strata are usually met below 100 feet (30 m), but once pipes are lowered, the level of water comes to within 15-20 feet (4.5-6 m).

Methods of construction

Two types of boring-system are in use in West Bengal : one is known as the sludger system and the other as the water-jet system. In the sludger system, a tripod is erected and a pointed boring-pipe is driven into the ground. The outside of the boring-pipe is coated with cow-dung mixed with water to make the ground soft. The boring-pipe is driven into the earth by working it up and down with a lever. This method is not recommended, however, as there is a chance of the strainer's being damaged during the process of boring. It has been found that a well constructed in this way yields contaminated water for a long period, and it is sometimes two or three months before the water drawn from the well is safe for use.

The water-jet system is considered to be the simplest and best. With this system, water is forced through the boring-pipe by pressure, and the boring-pipe with a cutter attached to it is rotated from the top. Earth, mixed with water, comes out through the annular space between the pipe and the ground. After the bore has been made to the required depth, the boring-pipe is withdrawn and the tube-well pipe, with filter, is lowered into the bore. It has been found possible to bore to a depth of 1,200 feet (360 m) without using a casing-pipe. This system of boring is recommended as there is no chance of the strainer's being damaged. The present cost of a 1½-inch (3.8-cm) diameter tube-well, 350 feet (106 m) deep, is 1,200 rupees ($252.00), the price of 1½-inch diameter galvanized-iron pipe being 1 rupee 12 annas per foot ($1.15 per metre).

Materials used for construction

Tube-wells vary in depth according to the soil formation of the locality. In the Sundarbans area of lower Bengal, which is still in the process of delta formation, drinkable water is found at a depth of 500 feet or more (150 m). Any water tapped from above this depth is found to be saline.

Asbestos-cement pipes. A year ago, asbestos-cement pipes were sunk to a depth of 150 feet (45 m), and these wells are yielding sufficient water of a good quality and bacteriologically pure. In two cases, however, this method of construction failed, as it was not possible to go deeper than 150 feet and the quality of the water was unsatisfactory. The pipes were joined by means of collars made of aluminium foil and filled in with plastic bitumen. The cost of such a tube-well, 150 feet deep, is 600 rupees ($126.00).

Bamboo pipes. Experiments were made on the use of bamboo pipes for shallow tube-wells. This gave sufficient water, but as the joints could not be made adequately, the quality of the water from a bacteriological point of view was unsatisfactory. Such water, however, was used for domestic purposes other than drinking. The tube-wells were sunk to a depth of 40-50 feet (12-15 m). (It should be stated here that it is rare that water is struck at this depth, unless it is in a river-bed or on the banks of a dried-up river.) The strainer was also made of bamboo, and covered with fine nets.

Galvanized-iron pipes. Galvanized-iron pipes are generally used for the construction of tube-wells 150-1,200 feet (45-360 m) deep. Such pipes have been found to be most satisfactory, and can be sunk to a depth of 1,200 feet with the simple tools and plant mentioned above. Tube-wells with diameters of 1¼-8 inches (3.2-20.3 cm) have been sunk for water-supply to municipalities, hospitals, public institutions, camps, colonies, and other small communities. One such tube-well, 150 feet (45 m) deep and 1½ inches (3.8 cm) in diameter, costs about 500 rupees ($105), the materials required being : 1½-inch-diameter pipe, a 12-foot (3.6-m) strainer, hand pump, check valve, and masonry platform with spill-water drain.

Quality of water from different sources

Studies on rural water-supply carried out in an area near Calcutta by the late Professor K. Subrahmanyan and Professor Bhaskaran of the All-India Institute of Hygiene and Public Health, Calcutta, during the period 1944-6, show that " ... tube-wells in this area yield water of a quality that is not significantly affected by the degree of sanitary conservation or lack of it at the surface, the mode of usage, depth of strainer, or location of well. It is very slightly affected by change of seasons. The open wells and tanks do not yield waters of such purity, and their quality is more readily changing with the seasons ".[1] The bacteriological examination of 3,586 samples from tube-wells during the course of two years showed that 80% of the samples were bacteriologically pure. Most of the contamination was due to the use of an open type of pump for drawing the water. Contamination was also attributed to the use of polluted water for priming these pumps. The same report states that the quality of the water in the tube-well samples may be considered to be the highest attainable by any uncontaminated ground-water, allowing for various contingencies, under practical conditions in rural areas. Experiments have also shown that if the open wells are fitted with pumps and covered by concrete slabs, the quality of the water improves and the number of coliform bacteria can be reduced to less than 100 per 100 ml in 75% of samples.

In some parts of West Bengal, water from tube-wells contains iron to an undesirable degree. In such cases, small iron-elimination plants are installed. The average depth of tube-wells in West Bengal is 350 feet (106 m), except in the Sundarbans area of lower Bengal.

Maintenance

The question of maintenance of small tube-wells scattered all over the province is a very difficult problem, mainly due to the absence of communication facilities. West Bengal has very few metalled roads and many villages become unapproachable during the rainy season. The yearly cost of maintenance of tube-wells varies from 4 rupees 8 annas ($1.00), in districts with good communications, to 13 rupees 8 annas ($2.80), where communications are poor. Since the Indian Independence Act of 1947, the Government

[1] Subrahmanyan, K. & Bhaskaran, T. R. (1948) *Indian J. med. Res.* **36**, 211

has taken over the responsibility of maintaining all rural water-supply sources and has spent nearly 5 lacs [2] of rupees ($105,000) a year for the purpose.

In certain areas of West Bengal, water is generally hard and contains magnesium and calcium salts. These salts form a very hard scale on the strainer, especially if the iron content of the water is high. It is difficult to remove such scales, but several effective methods are in use. The average life of a small tube-well in lower Bengal is found to be 11 years.

Efforts made by the State to improve rural water-supplies

In rural Bengal there is an acute scarcity of drinkable water. At present there is less than one source of safe water for every 900 persons. This is certainly inadequate. The Bhore Committee recommended that there should be at least one source for every 400 persons, which means that the number of sources of good drinking-water would have to be doubled.

The Government of West Bengal has been spending 12 lacs of rupees ($252,000) a year since 1947 for the sinking of tube-wells and masonry wells, where surface-water is not available. Under a recent development scheme, 8,600 tube-wells and 350 surface-wells have been sunk during the period August 1947 to December 1952. The total number of tube-wells which are functioning at present is 22,446.

In some areas, such as in the districts of Birbhum and Bankura, and in certain parts of Midnapur and Burdwan, tube-wells are unsuccessful owing to the crystalline soil-formation. Here, rural water-supply for masonry wells and earthen-ring wells becomes difficult during the hot weather when the water-level sinks to 40-60 feet (12-18 m) below ground-level. Drawing water by means of deep well-pumps becomes difficult, and maintenance of such pumps in out-of-the-way places is a serious problem. In many cases people have removed the slabs and the pumps and have taken to the old system of rope and bucket.

Conclusion

In villages of West Bengal the houses are scattered and the villagers poor; for these reasons piped water-supply is, for the present, out of the question. Tube-wells of small diameter—1½-2 inches (3.8-5 cm)—are the ideal source of safe water.

With the completion of the River Valley Projects, electricity will gradually become available in rural areas. It is also expected that, by means of integrated development of rural areas, under the Community Development Projects, the general standard of living and ideas on environmental sanitation will improve. It would then be possible to sink tube-wells with

[2] 1 lac = 100,000

large diameters of, say, 3-4 inches (7.5-10 cm). Water could be drawn by means of an electric pump, and stored in a number of reservoirs. It is reasonable to assume that, by these means, one or more villages could be supplied with water at much less cost in capital and maintenance.

In areas where tube-wells are not successful, infiltration wells on river-banks, or large surface-wells, would be the best source of water for villages. Water could be pumped by means of electric pumps and stored in a central reservoir. Infiltration water does not generally require further treatment. It is usually safe, clear, and free from mineral content and bacterial contamination.

It is difficult to assess with any degree of accuracy the amount of positive health benefit that has accrued from the increase in sources of water-supply in rural areas, but the number of deaths due to gastro-intestinal diseases is decreasing.

SOME ASPECTS OF THE PROBLEM OF POLLUTION OF COASTAL WATERS IN IRELAND *

Ireland is a small island of some 32,000 square miles (51,200 km^2), with a lengthy coastline along which the bulk of the population is concentrated. There are 13 cities and towns of over 10,000 population, of which 12 discharge sewage to the sea. In the 26 counties in 1936 there were 436 centres of population of 200 and over, with a total population of some 1.25 millions, and of these, 103 centres with a total population of 873,000 were situated on the coast and discharged their sewage into the open sea or into the larger tidal estuaries. It is estimated that one-quarter of all towns, representing two-thirds of the sewerable population, are directly concerned in the subject of sea outfalls.

The civil engineer's principal contribution in the past to the health of civilized communities has been the provision and safeguarding of piped water supplies. The methods whereby these supplies are obtained and the tests which they must pass as to sanitary and aesthetic qualities are standardized, and the public-health records in recent years bear ample testimony to the great improvement which has resulted from the advanced treatment and analytical control which have been put into practice. Unfortunately, the same cannot be said with regard to the safe disposal into coastal waters of the sewage which results from the provision of water supplies. Much information is available regarding sewage disposal into the fresh water medium, but relatively little where the diluent is sea water.

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