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WATER AND SANITATION FOR ALL: PARTNERSHIPS AND INNOVATIONS

Small-scale 'sand abstraction' systems

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THE SYSTEM OF abstracting water from the underlying water bearing sand of surface dry river beds is well established in Zimbabwe. References to the system go back to the 1920's and many installations were undertaken in the 1950's. Within Zimbabwe the system is erroneously but commonly, referred to as "sand abstraction".

The system works best in large slow flowing rivers which cross extensive plains below the water-shed. Conditions for sand abstraction are ideal where large rivers cut through igneous soils. In these areas soils tend to contain a large proportion of coarse grained sands, which are carried into and then remain in the river system. In long stretches of a river where the sand builds up to two or three metres or more, large volumes of water are retained. Whilst not condoning the disastrous effects of erosion it can be appreciated that such water supplies are a positive spin-off from the overall negative effect of high rates of soil erosion.

The system is inappropriate in small fast flowing rivers, high on the water shed which contain small amounts of unstable sand. However, by constructing a sand dam 'sand abstraction' can be made to work on smaller rivers which carry significant amounts of coarse sand. The impoundment, generally a weir, is constructed so that the basin will silt up over several years. By building the weir a little at a time and raising the full length of the wall by some 0.3 metres to 0.5 metres a year, only coarse grained sand is impounded, the finer silt being washed out of the weir each year.

The system is dependent on water freely percolating through sands to the point of abstraction. Silt and clay create an impenetrable barrier within an abstraction system and thus in such conditions "sand abstraction" is not an appropriate option. The ideal site is one above a natural rock barrier or in a depression of the river (formerly a pool) which is continually recharged by water percolating from an expanse of sand above.

Methods of abstraction

Each method allows the water which is retained in the river sand to be easily abstracted, leaving the sand behind. The technology is in fact based on traditional methods and from that several systems of "sand abstraction" have been developed over the years. Present day systems are dependent on equipment which can be installed into this water bearing sand and at all times remain in free moving water. Systems range in size from large mechanised schemes with diesel or electric powered pumps on the bigger rivers which irrigate several hundred hectares to small-scale hand operated pump and well screen units irrigating less than one hectare.

Traditional

In principle the technology is well accepted as rural people have traditionally been drawing water from the sand of suitable rivers for generations. As the water in a seasonal river drops below the surface of the sand so people excavate to the water bearing layer. Typically now, a discarded drum with no top or bottom is driven into the wet sand and the sand scooped out from within. This allows for some 150mm of standing water, a light cover is placed over the drum to protect the 'well' from drifting sand.

Infiltration galleries

This is the earliest method consisting of horizontal pipes running from the water bearing sand of the river into a sump or false well dug in the river bank to a depth greater than the river water level. It is most important to keep sand out of the system so that water gravitates easily into the false well. Well screening makes a suitable gravity abstraction pipe and modern, non-rotting synthetic fibres have improved the potential of the system in effectively keeping the pipes clear of sand. Before the advent of this technology it was difficult to keep pipes clear. It is still difficult to ensure that the pipe system is set sufficiently deep in the sand to maintain it in water at all times. It is very labour intensive to install but is relatively inexpensive and does not require complex equipment or expertise. A windlass or commonly used hand pump can be utilised to draw water.

Well screens

Short lengths of well screen make very suitable abstraction pipes. Well screening is PVC, plastic or styrene piping with transverse slots tapering from the inside to a narrower outside width. Slots at their narrowest are generally 0.5;1.0 or 1.5 mm wide and are selected according to the coarseness of the river sand. The slots prevent the entry of sand with a grain size of a greater diameter than the slot and the taper prevents sand grains wedging inside the slot and clogging the pipe. Smaller sand is initially drawn through the slots but coarser sand quickly collects around the immediate screen and by degrees blocks the entry of finer sand; thus a natural, graded filter is developed. One or more well screens are connected to a suction pump on the river bank by a flexible Polyethylene or rigid uPVC pipe.

The installation can either be carried out when the water is deep in the sand merely by digging the entire system in by hand, or when the river sand is saturated to full depth by 'jetting' in the well screens. In this induced 'quicksand' situation well screens can be easily pushed into the lower levels of river sand. Such a liquid sand effect can be produced with a motorised centrifical pump drawing water from a temporary supply in a tarpaulin. The resultant jet of water from the pump is directed straight into the sand, the well point is then pushed in as the jet goes down. This installation system is dependent on relatively, technically complex equipment and on materials which are not always readily available. It does however enable a very simple pumping system to be quickly established.

Manifold and well points

This system is not dependent on sand being kept out of abstraction pipes but is dependent on a velocity of water sufficiently low at the point of abstraction to draw off water without drawing sand into the system. It is best installed towards the end of the dry season when the river water level is at its lowest point. River sand is removed to water bearing level, a large diameter pipe (a manifold) is laid on the water yielding sand and slotted pipes which are driven into the sand at an angle are connected to the manifold. The manifold is also connected to a suction pump on the river bank. The number of well points, size of manifold and piping to the river bank are calculated according to the velocity of water in each part of the system, and on the quantity of water required, This system utilises a lot of commonly available material and is probably most usually employed in larger systems where engine driven pumps are used. It is doubtful if every installation is correctly calculated and many schemes experience problems of clogging with sand and of inadequate priming of mechanical pumps. This latter problem can be overcome with the installation of a priming tank on the supply line.

Caisson

Water is abstracted through the slotted base of a large (1.0 to 1.5m diameter) flat, cylindrical or slightly conical tank or 'caisson' which is connected by pipes to a suction pump on the river bank. The 'caisson' is dug into river sand as deep as possible and is lowered as necessary i.e. as the water level drops during the season, in order for it to remain in water. As with any of the systems, the installation is completed once a level has been reached which remains in water year round. This system is more awkward with the continual re-digging and lowering but because of the large surface area for abstraction it can sometimes be used where silt tends to accumulate, provided there is adequate recharge to the immediate area of the caisson.

Recharge

Once a system has been correctly surveyed and designed it is relatively easy to monitor and maintain. Unlike the recharge of ground water, which occurs slowly during and initially after the rainy season, recharge of a 'sand abstraction' system is immediate from a flowing river. It must however be noted that the river will continue to drain through the sand, the sand merely impedes the drainage. Thus the longer or more frequently the river flows and recharges the river basin, the longer the river takes to drain and the longer the system remains in water.

There is no water table or aquifer at the point of abstraction. As well as water percolating into the abstraction area, water is also draining away from the site. In less than optimum sites, water can completely drain away, leaving the system high and dry.

Water quality

Where there are extensive sands the entire river basin acts as an enormous sand filter bed. Where abstraction is not excessive and provided there are not large herds of cattle polluting the sand, the water may be considered potable and require no further treatment. Tests carried out on water drawn from several potential sites, revealed remarkably low levels of e coli contamination and very few impurities. Excessively used river sites, however, can become clogged and fouled from clay and/or livestock droppings.

Uses

- Human consumption - drinking, washing, cooking: A properly managed "sand abstraction" system provides a suitable source of water for domestic use. The limitation being that without engine powered systems the water is not easily moved to any distance from the river bank.
- Livestock watering: Even in less than optimum conditions "sand abstraction" systems provide a very suitable source of water for livestock. Whenever possible during the rains, farmers will always allow their animals to drink directly from the river. However once water levels in the river have dropped below the surface, water must be drawn by container. A simple pump, either driven directly into the sand and discharging into a trough on the river sand, or a more complete system drawing water onto the river bank to a supply point are both appropriate for livestock watering systems.
- Small irrigation schemes: Particularly where gardens can be established on low river banks, above the flood line and not too distant from the river edge, sand abstraction systems provide an excellent, low cost, option to convey water to nutrition gardens. One small hand pump is generally sufficient to adequately water more than 200m² of garden - an average size brushwood fenced garden.

Pumps

Probably the most appropriate and duplicable hand pump is a very simple 'suction' pump which draws water from

the sand to a low level sump on the river bank. For greater lifts a second pump, either a suction pump or a force pump, depending on the head, can be utilised to deliver water to a further distribution point or garden site. Provided water levels do not drop below any abstraction point, hand pumps can guarantee a safe, year round water supply.

Village level operation and maintenance

- As the simplest, low lift suction pumps can be used and as all systems and components of the systems are basically accessible the system is highly sustainable. Only a minimum technical knowledge is required, only a very few spares and tools are required and repair and maintenance is easily effected.
- In some fast flowing rivers there is the possibility that the river in flood will wash the abstraction point of systems away. However, merely by digging, these can be reinstalled by the end-users.
- Occasionally some rivers contain fine silt layers which move through the river sand and can eventually clog an installation. Good initial siting based on the knowledge of local people would generally preclude an installation at such a site.
- In general there are many large rivers with relatively low banks with many good possible sites where small scale, hand operated units can be installed, managed and maintained by either an individual or by trained and equipped community representatives.

Practical experience

Dabane Trust staff have installed some 25 hand operated 'sand abstraction' systems based on the Rower pump. A typical installation consists of a short well-screen as a well point with a Rower pump installed on the river bank just above the flood line. In our experience the Rower pump has drawn water from 60.0 metres and from a depth of 4.5 metres so is quite suitable in most applications even when the water level drops 1.5 - 2.0 metres in the sand at the end of a dry season. Water from the Rower pump discharges directly into a 0.75m³ subsurface sump. A second Rower pump in the garden some 30 to 40 metres away draws water from the base of this sump. This pump is built alongside a 3.00 m³ tank so its water discharges directly into the tank. In this manner water can be raised more than 8.00 metres and drawn from a distance of at least 100 metres.

Acceptance of and capability with the system has been very good. Women with virtually no technical skills at all have quickly gained confidence and learned to undertake all basic maintenance and repair work. There has been a very good acceptance of the technology from the gardeners, 95 per cent of whom are women. They have been pleased with the results of such a 'passive', low technology system and have noted of a general lack of involvement in the garden by some men who would otherwise interfere. The women have cited the sustainability and low operation and maintenance costs, in addition to increased self reliance as reasons for their preference for using this system in their gardens.

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