Design and performance of a community-level iron removal plant

by Cecil Chibi

A simple iron removal plant can make water taste, smell and look better. This system will satisfy local desires for clean and safe water.

IRON IS FOUND in groundwater throughout the Lowveld region and in the semi-arid areas of the northern Transvaal. Many of the rural areas are served by handpumps which yield water with iron concentrations well in excess of the World Health Organisation (WHO) upper limit of 1.0mg/*l*. Concentrations exceeding 20mg/*l* are noted frequently, and result in taste, odour, and colour problems. Upon contact with oxygen in the air, soluble iron compounds in the ferrous form are oxidized into insoluble ferric compounds, which are responsible for the colour problem. Unpleasant taste and odours arise from the decay of some organisms (iron bacteria) present in iron-rich water. Because of these aesthetic considerations, rural people generally refuse to use tube-well water in iron problem-areas, and they are more inclined to use unprotected surface water sources.

In an informal survey around the Majaneng area near Hammanskraal it was found that people would be willing to pay a reasonable amount of money if a low-cost iron removal unit were to be developed. Thus a primary consideration in the design and development of the plant was to ensure the use of readily obtainable materials so that with a little technical guidance any household would be able to construct their own treatment unit.

Plant design

The first system tested comprised four different chambers. The first was an aeration stage in which water was sprayed over charcoal, and the second was when the precipitated iron was allowed to settle. Stages three and four were merely where two different-sized media were used to strain the unsettled iron precipitates. Although the water quality from the system was very good (<1mg/*l*), the system was considered too bulky and therefore unsatisfactory. After further investigations, the compact system shown in Figure 1 was designed and constructed, featuring a 200-litre drum and pieces of guttering as the main components.

The aeration channel is made of a 100cm-long, 10cm-diameter polyvinyl chloride (PVC) pipe, which is capped at the two ends but has an inlet opening near the right end and an outlet opening near the left end of the pipe. About half the depth of the pipe is filled with 2 to 3cm charcoal chips. The inlet of the pipe is made to take water coming from the spout of a tube well. Water entering the PVC pipe flows horizontally over the charcoal chips till it drips through the perforated bottom end of the pipe into another channel, which is half-filled with granite chips. The water is suffi-

A completed iron removal unit in a homestead yard.

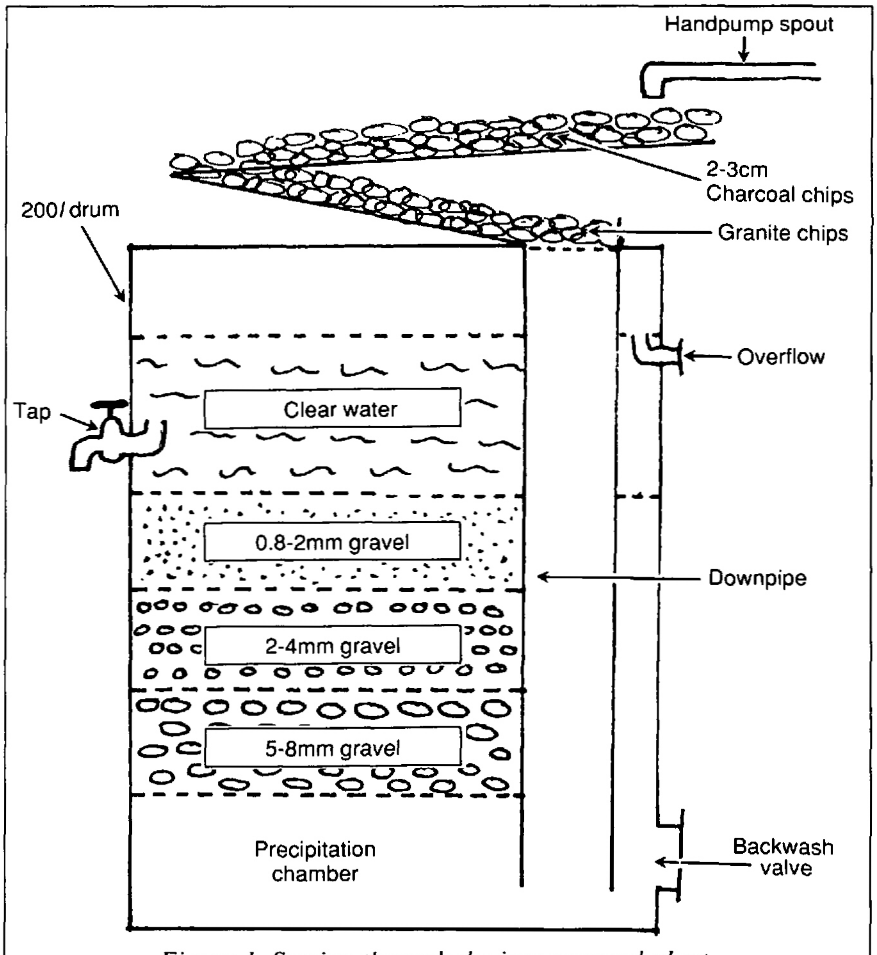

Figure 1. Section through the iron removal plant.

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ciently aerated because of the increased contact with air.

The aerated water then drips through the downpipe into the sedimentation chamber, which has a minimum retention time of five minutes. At this stage a portion of the precipitated iron particles settle at the bottom of the chamber. Because of pressure differences within the downpipe, the water then flows upwards through three differ-

Using the iron removal plant: note tubewell behind to the right.

ent layers of successively smaller gradings of gravel and sand.

The treated water is then collected through a tap. The filter is cleaned by opening a valve at the bottom of the drum, so that water flows quickly down through the sand, flushing out the accumulated deposits.

Tables 1 and 2 show the performance of the plant in removing iron as well as turbidity. They show results from start-up until the unit reached steady-state after about 13 days of operation.

The maximum hydraulic loading rate attained was about 10l/min, after which fluidization occurred. This implies a surface loading of about $3m^3/m^2/hr$.

Implementation

At a community meeting held in May 1989 at Majeneng it was resolved that a unit should be installed in one of the homes in the community for evaluation. If it proved satisfactory, then a second one would be installed at another well-stand where interested people from the neighbourhood could help build it and would thus learn enough

Table 1: Iron content of raw and treated water

Day	Raw (mg/l)	Treated (mg/l)
1	9.50	2.25
2	10.30	2.50
3	10.50	2.25
4	10.00	5.25
5	11.50	2.30
6	0.46	0.12
7	14.25	0.76
8	8.75	0.41
9	10.25	0.40
10	13.00	0.18
11	36.25	0.39
12	14.75	0.20
13	19.75	0.24

Table 2: Turbidity of raw and treated water

Day	Raw (mg/l)	Treated (mg/l)
1	95	38
2	63	30
3	73	70
4	64	47
5	105	24
6	65	23
7	84	14
8	56	7
9	73	7
10	79	5
11	117	9
12	78	8
13	87	7

to go on to build more for themselves.

The unit was set up next to a community handpump. As a precaution against vandalism, the community proposed that the unit be installed in the yard of a householder next to the tube-well.

Turbidity and total iron content was monitored fortnightly for about two months, and thereafter monthly. Over the six months the plant was monitored, and the iron and turbidity removal efficiencies were in excess of 90 per cent.

The following views emerged when individuals were interviewed about the iron removal unit:

- Where previously the raw, rusty water from the tube-well would stain their china and discolour their porridge and laundry, the treated water from the iron removal unit was much better.
- The fact, however, that a user had to carry a 25l container from the tube-well to the drum filter (a distance of about 10m) proved somewhat unpopular. It was strongly suggested that a unit which would treat the water direct from the spout would be even more welcome. The community would be keen to contribute towards such a system should the need arise.

Taking into account user's views, a new prototype has been developed. It works on the principles of aeration and uses South African tubewells, which usually have a spout height of only about half a metre, and therefore could not be connected to the initial iron-removal unit. In the new unit the air is introduced into the water though the sucking action of a venturi valve, which eliminated much of the loss in head experienced initially. The water then goes through a sedimentation chamber, overflows into the filtration chambers, and finally goes out through another spout and into a receiving container. The unit has not yet been fieldtested.

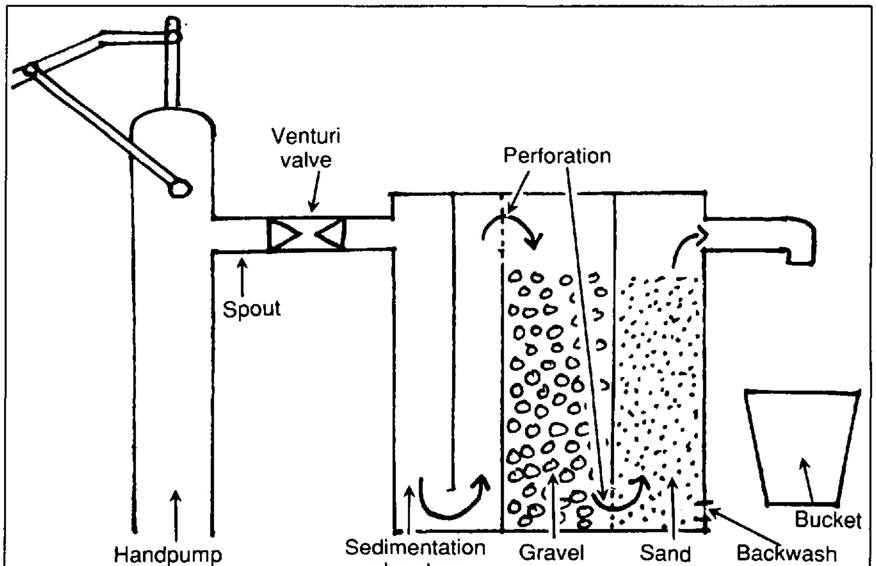

Figure 2. The new prototype iron-removal plant.