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Rural Development and Cooperatives
Department of Public Health Engineering

Government of The Netherlands
Ministry of Foreign Affairs
Directorate General of
International Cooperation

NETHERLANDS - BANGLADESH DEVELOPMENT COOPERATION PROGRAMME
DPHE - WATER SUPPLY AND SANITATION PROJECTS

Evaluation of Performance of Iron Removal Plants

- Start up in Habiganj
- Performance tests in Serajganj and Gopalganj

dossier E1898-01-001

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Programme Office, Netherlands Assisted Water Supply & Sanitation Projects
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1. INTRODUCTION

1.1. GENERAL

The 12 Sub-Divisional Towns Project, which is a part of the Netherlands-Bangladesh Development Co-operation Programme, started in 1981 with the upgrading and expansion of the water supply systems in 12 towns (locations figure 1.1) among which Habiganj (166 km north-east from Dhaka), Serajganj (130 km north-west from Dhaka at the right bank of the river Jamuna) and Gopalganj (155 km south-west from Dhaka).

On the basis of a water resources survey, which was conducted during the Master Planning phase of the project in 1986, it was decided to abstract groundwater in Habiganj, Serajganj and Gopalganj for water supply for reasons of costs and quality. The socio-economic survey (which was subsequently carried out) revealed that the households in Habiganj, Serajganj and Gopalganj were hardly interested in a house connection to the water supply system, due to the high iron content of supplied groundwater (table 1.1.) with concentrations up to 10 mg/l[1]. Therefore the systems in Habiganj, Serajganj and Gopalganj have been provided with an iron removal plant (IRP).

Table 1.1. - Groundwater quality

Parameter	Unit	Habiganj		Serajganj	Gopalganj
. depth aquifer	(m)	>90	<60	53-105	30-40
. pH	(-)	6.9	6.8	6.8-7.1	7.4-8.2
. electrical conductivity	(μS/cm)	250	320	400-500	1175-1320
. temperature	(°C)	24-25	27-29	27	27
. hardness	(mg $CaCO_3$/l)	130	170	200-400	45-220
. Fe(tot)=Fe^{2+}	(mg/l)	5-7.5	7.5-15	4.2-7.0	3-10
. Mn(tot)	(mg/l)	0.1	0.3	0.7-1.5	0.05-1.0
. NH_4^+	(mg/l)	0.3	0.7	0.2	3
. m-alkalinity	(mmol/l)	3	-	5	10.7
. Cl^-	(mg/l)	<5	-	44-54	30-200
. H_2S smell		no	no	strong	slight

The preliminary design of the IRP's was prepared in 1986 by DHV Consultants and the detailed designs in 1987 by Aqua Consultants. Subsequently work orders for the IRP's at Habiganj, Serajganj and Gopalganj were issued. In May 1992, January 1991 and June 1990 respectively the IRP's in Habiganj, Serajganj and in Gopalganj have been taken into operation.

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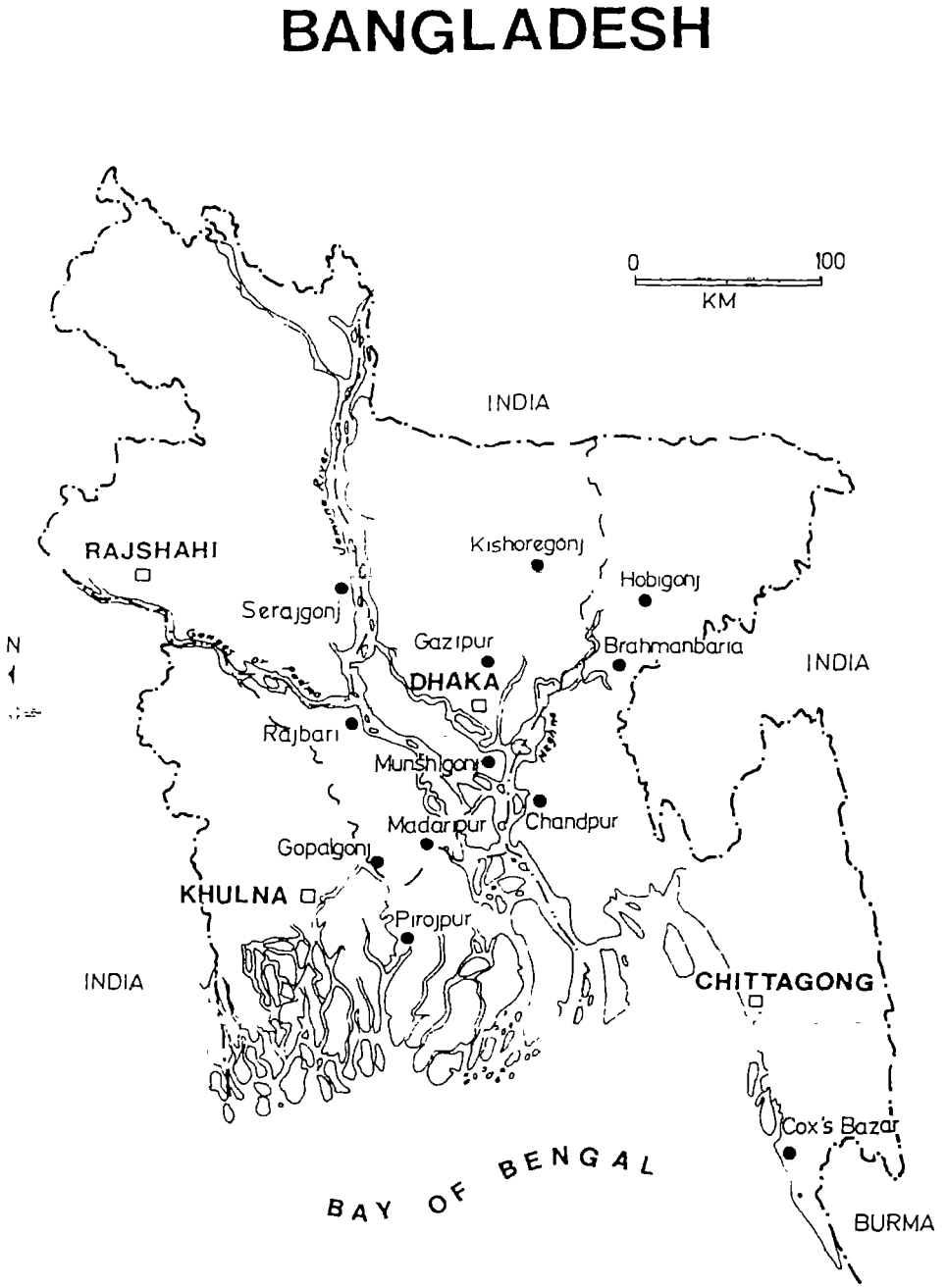
[1] The presence of iron in excess amount causes:
- taste and odour problems
- staining of laundry, and rice when cooked in such water turns brown
- obstructions in the distribution network by precipitating and forming deposits
- (possibly also) intestines problems

The maximum desirable and permissible iron concentrations in drinking water are 0.1 and 1.0 mg/l respectively according to the World Health Organisation

Fig. 1.1. - Twelve District Towns



In the period May 1992 technical assistance has been provided by DHV Consultants BV to DPHE related to:

- the start up of the IRP of Habiganj which covered:
  - . the putting in operation
  - . the performance of several trial runs
  - . the monitoring of the water quality
  - . the preparation of a technical operation and maintenance manual
  - . the introductory training of the operators

- the performance test of the IRP's of Serajganj and Gopalganj which covered:
  - . a general check on the level of operation and maintenance
  - . the performance of several filter runs
  - . the monitoring of the water quality

In connection with above mentioned activities the following documents have been used:

- Start Up Plan, Iron Removal Plant Gopalganj, June 1990
- Technical Operation and Maintenance Manual for the Iron Removal Plant in Gopalganj, Final Version, January 1991
- Logbook for the Iron Removal Plant in Gopalganj, January 1991
- Technical Operation and Maintenance Manual for the Iron Removal Plant in Serajganj, Final Version, January 1991
- Logbook for the Iron Removal Plant in Serajganj, January 1991
- Guide for Training of Operators of Iron Removal Plants in Gopalganj and Seraganj, January 1991
- Papers for Training of Superintendent and Sub-Divisional Engineer in Gopalganj and Seraganj, January 1991
- Evaluation of start up of Iron Removal Plants in Gopalganj and Serajganj, May 1991

- Preliminary design 12 Subdivisional District Towns B-group
  March 1985, DHV Consulting Engineers
- Preliminary design of iron removal plants for Serajganj and Gopalganj, December, 1986, DHV Consulting Engineers
- Master plan and Detailed design, final report Habiganj, 1986, AQUA Consultant and Associates
- Technical operation and maintenance manual Habiganj, on production wells, distribution system and consumer connections, March, 1990.

The following documents have been prepared:

- Technical operation and maintenance manual for the Iron Removal Plant in Habiganj, May 1992, DHV Consultants
- Logbook Iron Removal Plant Habiganj, May 1992
- Photo report Iron Removal Plant Habiganj, May 1992
- Photo report Iron Removal Plant Serajganj, May 1992
- Photo report Iron Removal Plant Gopalganj, May 1992
- This report

1.2. OUTLINE OF THE REPORT

The next chapters of this report give an outline of the activities which have been carried out in May 1992, related to the start up and the performance tests of the IRP's. Moreover some background information is provided on the IRP's.

- Chapter 2: "Basic Design of Iron Removal Plant"
  Gives the key elements in the design approach for the IRP's and describes the system parts. The general set up of the plants and the main dimensions and design data are supplied.

- Chapter 3: "Set up of trial runs and performance tests"
  Describes the trial runs of Habiganj and the performances tests at Serajganj and Gopalganj.

- Chapter 4: "Results of trial runs and performance tests"
  Contains the combined results of the trial runs of Habiganj and the performance tests at Serajganj and Gopalganj. In the different paragraphs the well performance, the water quality, the aerator and filter performance, back washing and wash water discharge, and the operation and maintenance is presented and discussed.

- Chapter 5: "Conclusions and Recommendations for the next period"
  Lists conclusions and proposed actions for the next period.

2. BASIC DESIGN OF IRON REMOVAL PLANTS

The basic processes in iron removal are:
- Aeration to convert the soluble ferrous compounds to insoluble iron hydroxide flocs.
- Filtration of aerated water to remove the formed iron hydroxide flocs in a filter consisting of a layer of sand.

A safety disinfection with chlorine (in the form of bleaching powder) of the filtrated water is carried out to prevent bacteriological growth in the distribution system.

To enhance the sustainability of the IRP's, the key criteria in the design of the IRP's have been:
- easy in operation and maintenance
- application of low cost technologies in order to enable the recovery of operation and maintenance costs
- application of local materials, equipment and labour to the largest possible extent
- presence of representatives of suppliers of imported equipment in Bangladesh

The general set up of the treatment plants of Habiganj, Serajganj and Gopalganj is listed in table 2.1. and the main dimensions and design data in table 2.2. In the next section, the system parts, which are shown in figure 2.1. are described.

2.1. WATER INTAKE

Raw water from the production wells enters the division chamber where it is equally divided over two units by means of overflow weirs. The water flow can be measured with the help of these overflow weirs (V-notches). For this purpose measuring scales are mounted and a conversion table is provided in the Operation and Maintenance Manuals of the IRP's.

2.2. CASCADES

From the division chamber, the water flows via the V-notches to the cascade aerators. For iron removal it is necessary to aerate the anaerobic raw water. The atmospheric oxygen brought into the water reacts above pH = 6.5 quickly with the dissolved ferrous compounds converting them into insoluble ferric hydroxides which can be removed by filtration.

The reaction is: $4\ Fe^{2+} + O_2 + 10\ H_2O = 4\ Fe(OH)_3 + 8\ H^+$

Manganese can also rather quickly be oxidised and removed if sufficient catalytic activity is present in the form of a manganese oxide layer on the sand grains:

$2\ Mn^{2+} + O_2 + 2\ H_2O = 2\ MnO_2 + 4\ H^+$

During aeration carbondioxide is simultaneously removed from the water, increasing the pH which in its turn increases the conversion rate of ferrous compounds to ferric hydroxides.

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Figure 2.1. - Iron Removal Plant

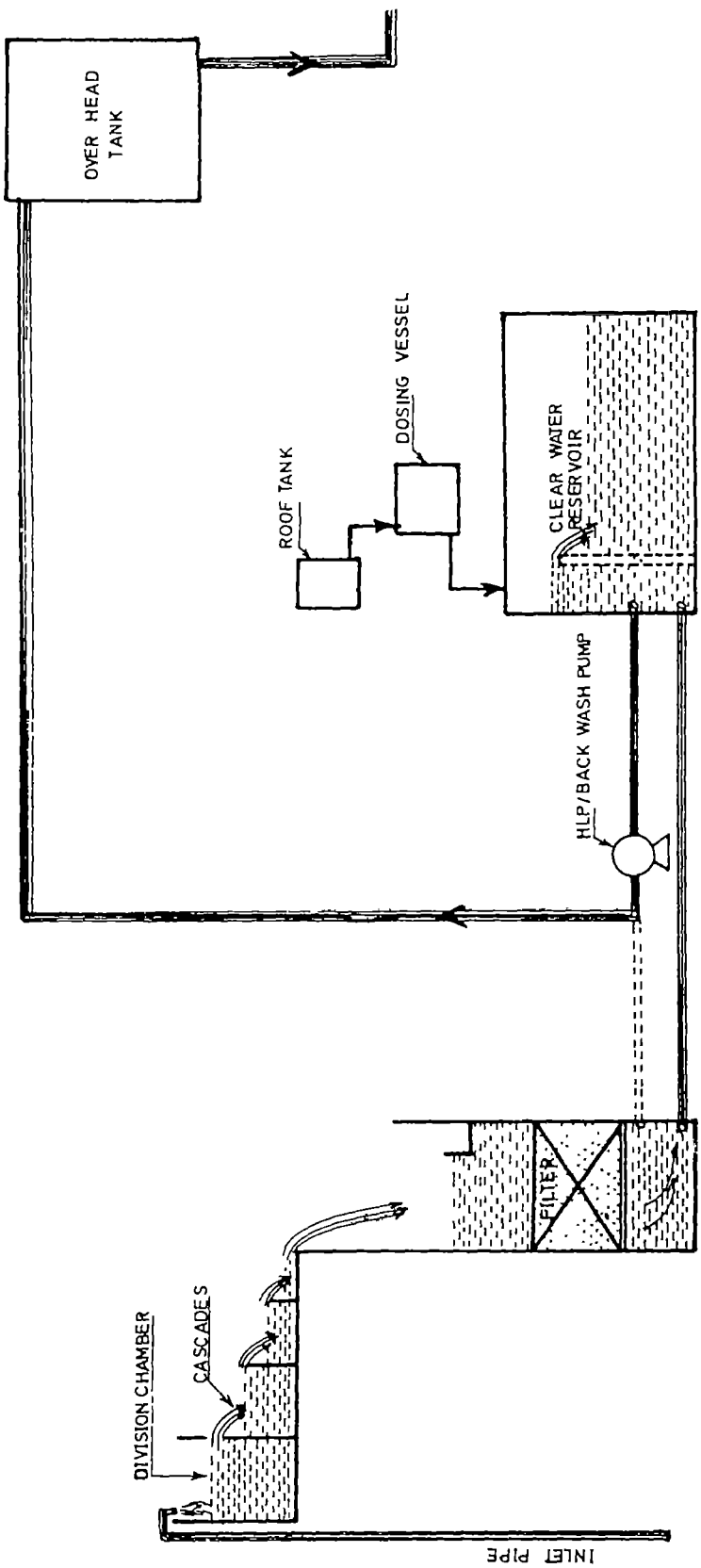


Table 2.1. - General set up treatment plants

Parameter	Unit	Habiganj	Serajganj	Gopalganj
- Capacity	(m^3/h)	204	204	140
- Start of operation	(-)	May 1992	Jan 1991	June 1990
- Number of production wells	(-)	5	3	7
- Number of division chambers	(-)	1	1	1
- Number of V-notches	(-)	2	2	2
- Number of cascades	(-)	2	2	2
- Number of filters	(-)	2	2	2
- Number of chlorination units	(-)	1	1	1
- Number of high lift/ backwash pumps	(-)	2	2	2
- Number of clear water tanks	(-)	1	1	1
- Number of over head tanks	(-)	1	2 (1 in use)	1
- Number of sludge tanks	(-)	1	1	0
- Number of sludge pumps	(-)	1	0	0

Table 2.2. - Main dimensions and design data

	Unit	Habiganj	Serajganj	Gopalganj
- Cascade				
. number of steps	(-)	3 (+2)	3 (+2)	3 (+2)
. fall height	(m)	0.9 (+0.8)	0.9 (+0.8)	0.9 (+0.8)
. oxygen input	(mg/l)	7-8	7-8	7-8
- Filter				
. surface	(m^2)	13.6	13.6	9.3
. bed height	(m)	1.5	1.5	1.5
. filtration rate	(m/h)	7.5	7.5	7.5
. filter medium	(-)	sand	sand	sand
. grain size	(mm)	1.2-1.5	1.2-1.5	1.2-1.5
. overflow height	(m)	1.7	1.8	1.4
. back wash rate	(m/h)	40	30	30
- Chlorination Unit				
. dosing tank volume	(m^3)	1.0	1.0	0.8
. solution strength	(%)	0.4-2.4	0.4-2.4	0.4-2.4
. dose flow	(l/h)	50-100	50-100	50-100
. bleaching powder dose	(mg/l)	2-6	2-6	2-6
- Clear water tank				
. effective volume	(m^3)	151	151	135
. residence time	(min.)	45	45	48
- Overhead tank				
. effective volume	(m^3)	682	682	682
. height	(m)	30	26	26
- Sludge tank				
. effective volume	(m^3)	125	146	-
- Sludge pump	(m^3/h)	130	-	-
- High lift/backwash pump				
. high lift capacity	(m^3/h)	204 at 30m	204 at 26m	190 at 25 m
. back wash capacity	(m^3/h)	>500 at 11 m	>500 at 9.2m	345 at 9.5m

For the IRP's in Habiganj, Serajganj and Gopalganj cascade aerators (the most simple case of gravity aeration) have been selected, as these cascades are very easy in operation and robust, require little maintenance and are effective for conversion of ferrous compounds to ferric hydroxides.

2.3. SANDFILTERS

After the last step of the cascades the water falls into the rapid filters (figure 2.2.). Rapid filtration is a purification process, whereby the water to be treated is passed through a porous medium at relatively high velocities. The filterbed consists of a 1.5 m thick sand layer. The grain size of the filter sand is 1.2 - 1.5 mm.

During the process of filtration the suspended solids are removed from the water, and accumulated on the sand grains and in the pores between te grains. Due to clogging of the pores, the resistance of the filter bed increases and consequently the water level on top of the filter rises. This water level is limited by an overflow pipe.

When the filter run period is proceeding, the iron concentration in the filtered water can slightly increase with time. At a certain moment, however, a steep increase in turbidity/iron concentration occurs rather suddenly. This is called the "break-through" of the filter. The suspended solids cannot be retained adequately any more by the filterbed so that the bed must be cleaned/regenerated.

The sand filters are designed in such a way that overflowing (maximum allowable water level) precedes the "break-through" of the filter bed (figure 2.3.). When overflowing is observed, the filter must be cleaned to remove the accumulated suspended solids to restore the original water level over the filter bed. This cleaning is carried out by backwashing the filter with clean effluent.

The time between two successive backwashes of a filter bed is called the filter run length.

Backwashing

Cleaning of a rapid filter is effected by reversing the water flow through the filter. This expands the filterbed and scours the grains, carrying the accumulated suspended solids to waste. The water of the clearwater reservoir is used for backwashing of the filters. After performing its duty in cleaning the rapid filterbed, the washwater is discharged via the backwash gutter and drain to the river.

The backwashing is the main aspect of the operation of the filters and requires the operation of several valves. It is initiated on basis of high water level by the operator.

Although combined air-water backwashing is increasingly practised nowadays, this method is not selected as the operation and maintenance of compressors (which supply the air) is rather critical and considered to be less suitable for application in Habiganj, Serajganj and Gopalganj. Moreover, backwashing with water only is also effective.

Filterbed material

The filterbed material is of utmost importance for the filtration process; sand is suitable filter medium because it is clean, durable and widely available (also in Bangladesh) at low cost. But as found in nature, the variation in grain size of the sand is too large; fine material gives a short filter run length due to rapid clogging, while coarse material does not add to effluent quality. Therefore the natural sand must be sieved to remove coarse and fine fractions. In practise of iron removal the diameter of the grains of the filter should be between 1.2 - 1.5 and the uniformity coefficient below 13.

Figure 2.2. - Aerator and Filter

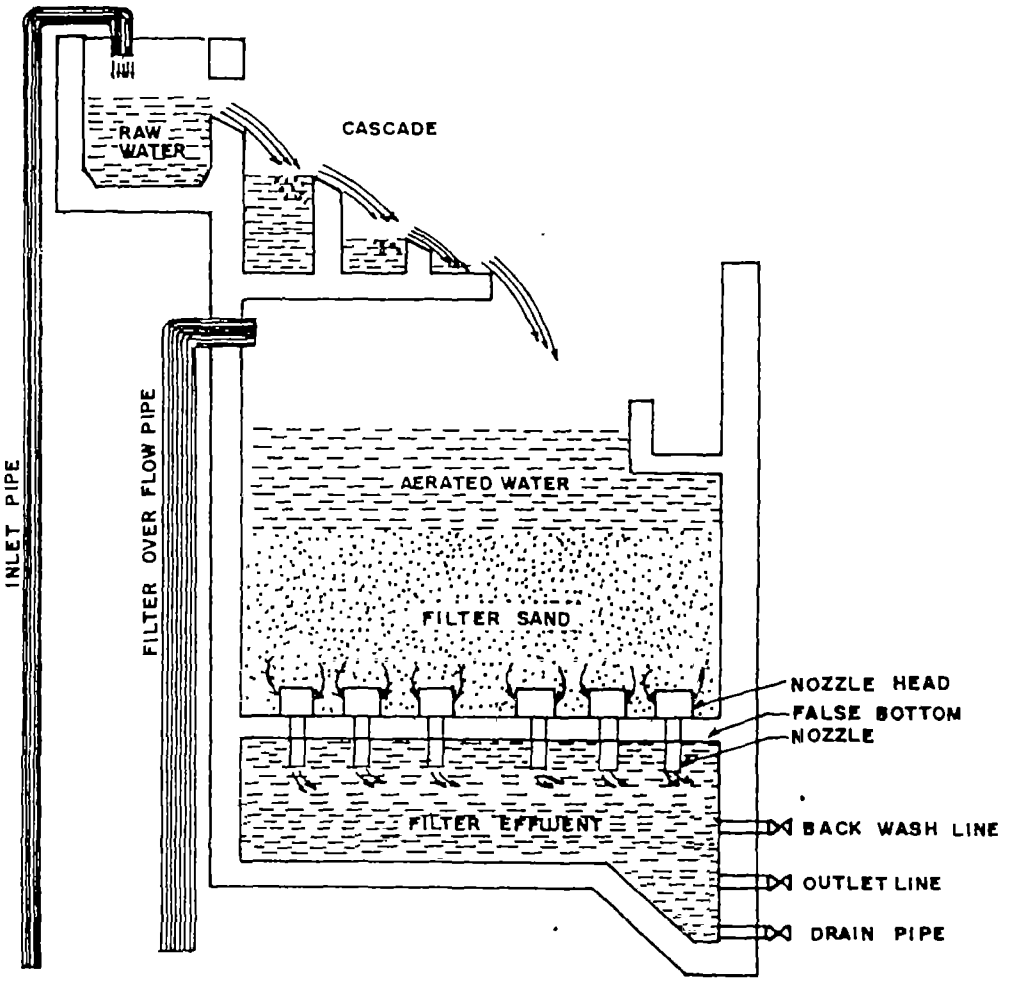
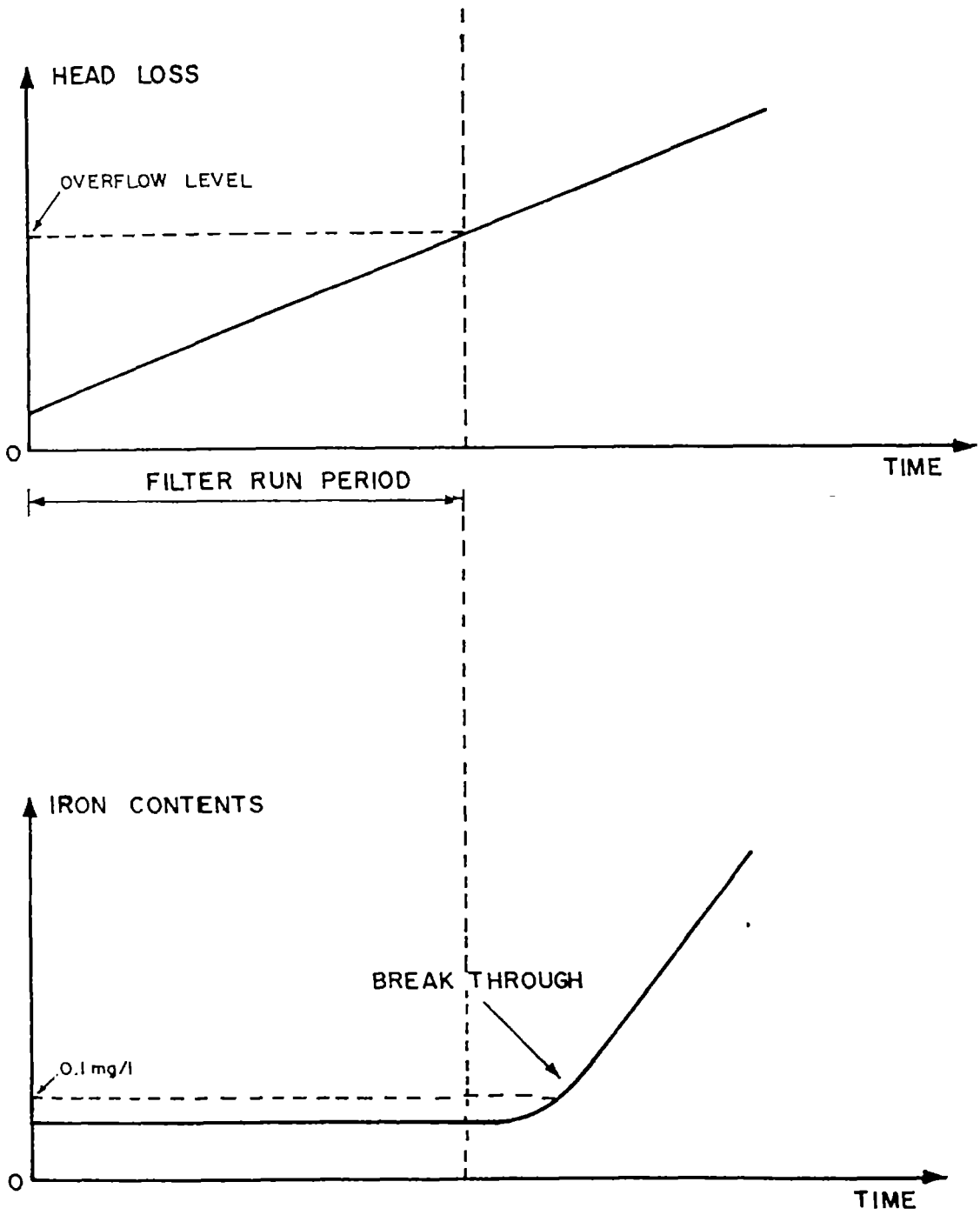


Figure 2.3. - Water Level over filter Bed and Theoretical Filter Effluent Quality during Filtration Run



2.4. CHLORINATION UNIT

The effluent of the filters is subjected to disinfection with bleaching powder (solution) which is dosed by a drip feed chlorinator, located above the entrance of the clear water reservoir. For Habiganj, Serajganj and Gopalganj a gravity dosing system has been selected as its operation and maintenance is more easy than that of pumped dosing systems.

The dosing system includes a feeder, consisting of a cap with a small hole in it, which controls the dosing (so that there is no need for further control devices).

The dosing rate of disinfectant (ca. 10-20 ml/s) depends on the filter effluent flow, the solution strength as well as the chlorine demand of the filtered water. It should be adjusted in such a way that the free chlorine content in the distribution system is:
- high enough to prevent bacteriological growth in the distribution system (>9.2 mg/l)
- low enough to prevent taste and odour complaints (<0.5 mg/l)

Adjustments in the dosing rate may be effected by selection of another feeder and/or by adjustment of the concentration of bleaching powder in the dosing flow

The main aspects of the operation of the chlorination unit is:
- closing the dosing valve at a power failure
- opening the dosing valve after a power failure
- the daily preparation of bleaching powder solutions (before start up)

2.5. CLEAR WATER RESERVOIR

The effluent of the rapid filters flows by gravity to the clear water reservoir which has a double function:
- storage of clear water for back washing
- contact chamber for disinfection; the disinfecting effect becomes complete after a contact time of at least 30 minutes

2.6. SLUDGE TANK

To prevent contamination of paddy (rice) fields and fields with other crops the backwash water is transported through a sludge tank and a pipe for discharge into a river in the cases of Habiganj and Serajganj. The sludge tank serves as a temporary buffer for the backwash water, and is filled under gravity.

2.7. PUMPS AND ELECTRICAL CONTROL PANEL

In the plants two (imported) centrifugal pumps (of which one stand by) have been installed. These pumps transport the produced water to the overhead tank, as well as provide backwash water (from the clear water reservoir) to the filters. Power supply and pump operation is controlled by an electrical panel. In the case of Habiganj also a sludge pump has been supplied.

3. SET UP OF TRIAL RUNS AND PERFORMANCE TESTS

A number of checks and tests were carried out and the installation disinfected before the start up of the IRP of Habiganj.

The start up includes three trial runs which are aimed at:
- characterization of the filter, so that the performance and operating schedule of the filters can (roughly) be predicted for various operating conditions
- testing of the backwash procedure
- setting of dosing of bleaching powder

The introductory training of the operators of the IRP in Habiganj can be simultaneous with the last trial run.

The performance tests in Serajganj and Gopalganj comprise the following activities:
- investigation of the state of maintenance of all plant components
- checking the operation of the plant by performing a filter run and backwash cycle
- interview of sub divisional engineer, superintendent and operators about operation and maintenance
- checking the logbook

In this chapter the relevant tests and activities are described.

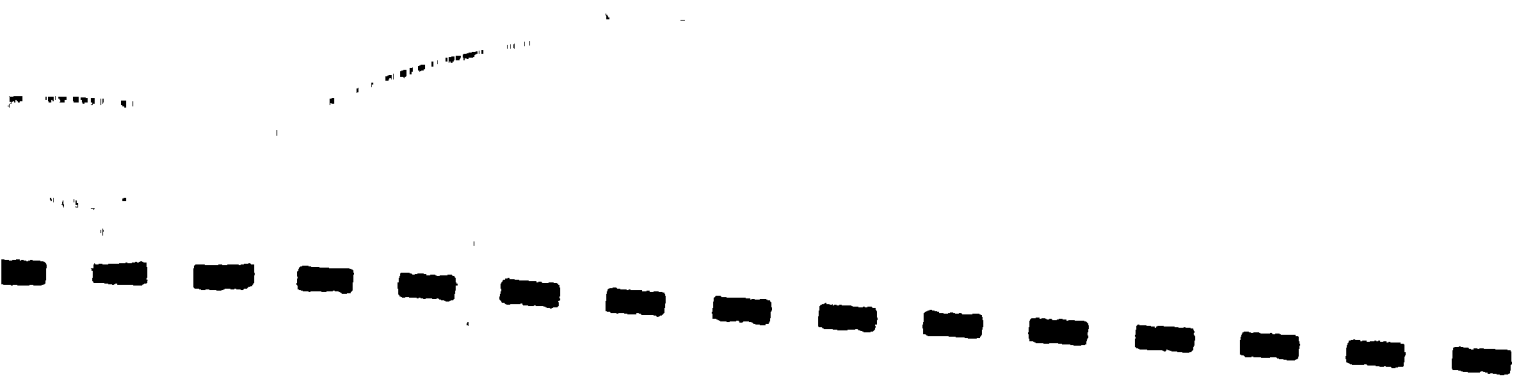
3.1. PREPARATIONS START UP HABIGANJ

Before the plant can be put in operation, the physical works to be done must be completed. The following start up preparations were made:

1. Operation of the wells and flushing the intake lines to remove sand and suspended solids and to check the intake sluice valves. Determination of the production capacities of the concerned wells.

2. A number of tests/checks were carried out:
   - mechanical/electrical checks on pumps and panels, including:
     . functioning of circuit breakers, on/off switches, control lamps, volt and ampere meters
     . presence of fuses
     . the trouble-free running of the pumps
     . transport of water from clear water reservoir to the overhead tank and check of the pump capacity
     . the operation of the low level cut-out device (which prevents that the pumps run dry)
     . functioning of high water alarm
   - calibration of the overflowing weirs
   - check if nozzles are vertically fixed
   - check if filter nozzles are open; for this test the flow should be reversed
   - functioning of water level indicator in the clear water reservoir
   - functioning of overflow of the filters and clear water reservoir

3. Hereafter the complete installation was disinfected with a bleaching powder solution (150 ppm). For this about 30 kg bleaching powder is required. The next day the disinfecting solution was drained off and the installation rinsed thoroughly.



4. Simultaneous with the disinfection of the installation, the final check on the filter bed material at the spot was carried out: at random 20 samples of 1 kg were drawn from 20 bags of sand. The fraction of grains smaller than 1.00 mm and larger than 1.65 mm were analyzed. The results were filled in on form 1 (appendix 2). The filter material was rejected if the fraction smaller than 1.00 mm exceeds 5-10% and/ or the fraction larger than 1.65 mm exceeds 25%.

5. After disinfection the installation and testing the filter material, the filters were prepared for operation. The procedure for preparation is:
   - wash the filter material before placing it in the filter bed
   - fill up the filter to 0.6 m
   - backwash the filter to check on equal distribution of wash water over the nozzles
   - fill up filter to 1.5 m
   - backwash for one or two hours to remove remaining dust particles
   - disinfect the filter bed with 150 ppm bleaching powder solution (to remove the micro-organisms). Per filter bed about 1.5 kg is required.
   - Drain off the solution after 12 hours
   - Rinse the bed thoroughly

The estimated duration of the checks, tests and disinfection of the installation and preparation of the filter is 2 days.

3.2. TRIAL RUNS HABIGANJ

During the trial runs the following water samples were analyzed on the in table 3.1. indicated parameters and frequency. At the same time the water flow and the head loss over the filter bed were registrated.

Table 3.1. - To be measured data

Parameter	Unit	raw water	aerated water	filtered water
frequency	(h)	every 6	every 6	every 2*
temperature	(°C)	+	+	-
pH	(-)	+	+	-
turbidity	(NTU)	-	+	+
oxygen	(mg/l)	+	+	-
total iron	(mg/l)	+	+	+
ferrous iron	(mg/l)	+	-	+
water flow	(m^3/h)	-	-	+
head loss	(cm)	-	-	+

* first hour every 10 minutes

These measurements were carried out by an experienced laboratory (zonal laboratroy of Comilla) and required laboratory equipment inclusive calibration standards, other auxiliary equipment and stock chemicals (appendix 1).

In addition the analytic instruments should be properly calibrated before use.

3.2.1. Trial Run 1: Operation of two aerators and filters at designed capacity

Filtration

Duration: appr. 2 days

The first trial run intents to characterize the filter at its designed capacity. During this run the chlorination unit is out of operation. The performance of the wells is also checked.

Before the start of the trial run the height of the bed was measured.
The trial run was stopped if the iron concentration in the effluent (nearly) equals that in the influent. The anticipated duration of this (continuous) run is about 40 hours (in case iron concentration in the influent is 4 mg/l). In this run the overflow of the filterbed was closed (normally the filter starts overflowing before the filter "breaks through").

For determination of ferrous compounds in the aerated water, samples were collected in an acidified sample bottle to prevent the oxidation of ferrous compounds to insoluble ferric compounds. The ferrous compounds can be analyzed by omitting the reduction step with an iron field test kit.

Note: For effective iron removal it is required that after aeration all ferrous compounds are converted to the insoluble ferric compounds. This conversion depends on the pH and oxygen concentration.

The collected data should be filled in on form 2 and 3 (appendix 2).

Backwashing

duration: 30-45 minutes

After filtration is stopped, the filter bed was cleaned at a filtration rate of 30 m/h. Before backwashing the backwash gutter is checked on sand. If present the sand was removed.
Every 2 minutes the turbidity of the discharged backwash water was measured 1 minute after the start of backwashing. The backwashing was stopped when the clear water tank was emptied.
After the backwashing:
- the height of the bed was measured
- the backwash gutter was checked on the presence of filter sand

The backwash rate was adjusted in a next run, if filter material is lost during backwash or if filter bed is not thoroughly clean.
The results of the analyses have to be filled in on form 4 (appendix 2).

3.2.2. Trial Run 2: Operation of the filters at designed capacity and establishing the bleaching powder dose

This trial run is aimed to:
- collect the same data as at trial run 1
- perform a jar test with filtered water to establish the bleaching powder dose
- to check the performance of the pumps
- to check the calibration of the V-notches

- to produce an excess of filtered water and store it in the overhead tank so that sufficient water is present to flush the distribution system at trial run 3

Both filters are operated during this run. The collected data were filled in on form 2 and 3. the backwashing is also carried out as described at trial run 1. The backwash data are recorded on form 4.

The jar test is performed with filtered water according to the description in appendix 3. The turbidity and total iron concentration of the filtered water were determined.

The performance of the high lift pumps is checked by pumping water from the clear water tank to the overhead tank under the following conditions:
- valves to distribution systems closed
- production wells off and filtered water valve closed

From the level drop in the clear water tank and the level rise in the overhead tank in a certain time the pump capacity can be calculated.
In the same way the capacity of the pumps at backwashing can be determined.
The calibration of the V-notches can be determined by measuring the level rise above the filter in a situation of closed filtered water and backwash valves.

3.2.3. Trial Run 3: Operation of the complete installation at design capacities

This run aims:
- to flush the distribution system
- to set the bleaching powder dosing
- to determine the free residual chlorine concentration, turbidity and total iron concentration in 5 tap samples

The sampling of the raw water, aerated water and filtered water including registration of flow and head loss was carried out in the same way as in the former runs, also for backwashing.
The bleaching powder solution was prepared and the dosing valve calibrated.
The distribution system was cleaned by opening the main wash outs one by one and flushing at the pressure of the overhead tank.
Five tap samples were analyzed on residual chlorine turbidity, total iron and the presence of coli bacteria after the dosing of bleaching powder solution has started and chlorinated effluent has been delivered to the distribution system.
The results were filled in on form 5, 6 and 7 (appendix 2).

3.3. PERFORMANCE TESTS SERAJGANJ AND GOPALGANJ

The performance tests in Serajganj and Gopalganj comprise the following activities:
- checking the well performance
- investigation of the state of maintenance off all plant components
- checking the operation of the plant by performing several filter runs and backwash cycles and a water quality monitoring programme
- interview of subdivisional engineer, superintendent and operators about operation, maintenance, failures and problems
- checking the logbook
- analysing the water quality of 5 tap samples spreaded over the entire distribution system

The investigation of the state of maintenance of the plant components include the following points:

- checking the presence of strange objects, sediments, and a bacterial slime layer in the:
  - . division chamber (including measuring scale)
  - . cascades
  - . filterboxes (including measuring scales)
  - . clear water tank and overhead tank
- checking on corrosion of:
  - . gratings division chamber
  - . stairs and platform
  - . inlet and outlet pipes, pipes inside IRP building
  - . valves inside and outside IRP building
- checking valves on leakage and ease of opening and closing
- checking pipes on leakage and damage
- checking the filter on:
  - . bed height
  - . presence of mud balls
  - . equal distribution of filtersand
  - . equal distribution of wash water during backwashing
  - . presence of sand in back wash gutter
  - . presence of sand in drainage water (this is an indication for (a) broken nozzle(s))
- mechanical/electrical checking of pumps and panels:
  - . functioning of circuit breakers, on/off switches, control lamps, volt and ampere meters
  - . presence of fuses
  - . trouble free running of pumps without strong noise and without vibrations
  - . checking the pump capacity at "high lifting" and backwashing
  - . transport of water from clear water reservoir to the overhead tank
  - . the operation of the low level cut out device (which prevents that the pumps run dry)
  - . functioning of water level indicator in clear water tank and overhead tank
  - . functioning of overflow of the filters and clear water reservoir

The operation of the plant was checked by performing two or more filter runs and backwash cycles. The same monitoring programme was carried out as at the trial runs of Habiganj. Both in Serajganj and Gopalganj support was given by the Zonal Laboratories of Rashahi and Kulna respectively.

The capacity of the production wells was determined and the state of maintenance was checked. From 5 taps spread over the entire distribution system samples were taken and analyzed on turbidity and iron.

Finally the operation and maintenance was discussed with the subdivisional engineer, the supervisor and the operators. The data registration in the log book was also discussed and checked.

4. RESULTS TRIAL RUNS AND PERFORMANCE TESTS

4.1. INTRODUCTION

The results of the trial runs in Habiganj and of the performance tests in Serajganj and Gopalganj are combined, presented and discussed in the following paragraphs of this chapter:
- well performance
- water quality
- aerator and filter performance
- back washing and wash water discharge
- operation and maintenance

The start up preparations were already made before arrival on Friday May 15, 1992 in Habiganj. These included:
- checking the grain size distribution and uniformity coefficient of the filter sand (the U.C.1.3) see data appendix 4). This result was reached after a second time sieving.
- removing sand and suspended solids from the intake lines by flushing
- cleaning and disinfection of the entire plant with a 150 ppm bleaching powder solution
- checking the functioning of pumps, valves, overflow pipes, filter bottom and nozzles, and the electrical system

The quality of construction of the plant (civil, mechanical and electrical works) is very high and so is the finishing touch. The contractor in cooperation with the local consultant has done a very good job. The plant performs also very well and produces a good filtered water quality.
The start up of the plant was unfortunately delayed with two days because of a very heavy tropical thunderstorm, which damaged two electricity poles and caused a power failure. The replacement of the electricity poles took two days.
Due to the fact that the Super Intendent was only partly and the operators were not present the introductory training could only partly be carried out.

The state of operation and maintenance of the Serajganj plant is good and a very good filtered water quality is produced.

In Gopalganj the operation and maintenance of the Iron Removal Plant is poor. Pump motors urgently need lubrication and all metal parts (pipes, valves, gratings, etc.) are corroded and have to be painted. Because of the too small water production (wells must be regenerated and new wells sunk) only one filter can be operated (total flow only 73 m^3/h). Back washing is not always carried out so that filter runs are short: only 3-4 hours. Normal filter runs of 13-15 hours could be realised at three times after each other back washing. The filtered water quality is very good.

4.2. WELL PERFORMANCE

The performance of the wells in the three District Towns is listed in table 4.1.

The operation and maintenance of the wells is good. Only in Gopalganj two pumps were leaking. One pump and pump motor was just repaired and the two leaking packings were going to be repaired the next day.

Table 4.1. - Well Performance (May 1992)

Well No.	Year of Construction	Capacity (m^3/h)	Iron (mg/l)	Hour counter (h)	Vibrations Noise	Leakage
Habiganj						
1	1962	(pump, pumpmotor and foundation need repair)				-
2	1963	40	3.1	0	no	no
3	1975	40	2.9	0	no	no
4	1988	120	3.4	0	no	no
5	1990	70	3.3	0	no	no
Serajganj						
1	1964	25	8.3	2766	no	no
2	1964	(choked up)				
3	1964	75	7.8	2722	no	no
4	1964	(not in use, not connected to IRP)				
5	1964	(not in use, not connected to IRP)				
6	1988	100	9.7	2698	no	no
Gopalganj						
1	1973	16	4.6	-	no	yes
2	1973	20	3.9	-	no	no
3	1973	12	4.2	-	no	yes
4	1979	(not in use, not connected with IRP)				
5	1979	(not in use, not connected with IRP)				
6	1988	25	3.3	-		
7	1988	(well out of order, screen is blown up during regeneration)				

In Habiganj sufficient over capacity is present especially if well 1 is repaired, which is the intention to be carried out in the near future.

In Serajganj there is just sufficient capacity and thus no overcapacity. The situation in Gopalganj is critical as only half the capacity is available. During the performance test one was busy to sink two wells.

Regeneration of the existing wells and connection of well 4 and 5 to the IRP intake system is advised to structurally improve the situation.

4.3. WATER QUALITY

The data of the trial runs at Habiganj and of the performance tests at Serajganj and Gopalganj are supplied in appendices 5, 6 and 7 respectively. A summary of the quality of the raw, aerated and filtered water is presented in table 4.2.

The iron is very well removed from 3.3, 7.2 and 3.9 mg/l in Habiganj, Serajganj and Gopalganj respectively below 0.3, 0.1, and 0.1 mg/l. These concentrations are below the maximum desirable values of the World Health Organisation in Serajganj and Gopalganj and far below the maximum permissable value in Habiganj.
It is expected that after several days the iron concentration in Habiganj will further drop and also reach a level below 0.1 mg/l. In this period the surface characteristics of the sand grains change by the formation of an Fe_2O_3-$Fe(OH)_3$ layer, which results in an improved filtration efficiency. The same phenomena was also observed in Serajganj and Gopalganj during start up the iron concentrations in the filtered water were around 0.3 mg/l and several days later below 0.1 mg/l.
The turbidity removal runs parallel with the iron removal because the turbidity is mainly caused by he insoluble and visible iron hydroxides.

During the second trial run in Habiganj the jar test for the determination of the bleaching powder dose was carried out with a filtered water sample (appendix 3). Due to the iron concentration of 0.4 mg/l and turbidity of 3.5 NTU a relative high bleaching powder dose (6 mg/l) turned to be necessary to obtain a free residual chlorine concentration of 0.5 ppm after 45 minutes reaction time.

Large amounts of iron containing sediments were discharged during flushing of the distribution system in Habiganj.
After dosing of 6 mg bleaching powder per liter filtered water the water quality at the nearest tap and some taps at the periphery were analyzed (appendix 5).
The total iron concentration varied between 0 1 and 0.22 mg/l and the free residual chlorine concentration between 0.2 and 0.6 mg/l, which is a very good water quality. Only at the Police station the iron concentration (5.3 mg/l) and turbidity (3.5 NTU) were too high. This part of the distribution system was obviously not flushed yet.
The free residual chlorine concentration is in the good range which implies that the chlorine dose is correct. It is expected that after a decrease of the iron concentration below 0.1 mg/l a smaller bleaching powder dose can be applied.

Table 4.2. - Summary of water quality and aerator and filter performance

Parameter	Unit	Habiganj	Serajganj	Gopalganj
- raw water				
. total iron	(mg/l)	2.9- 4.2(3.3)*	7.2-7.3	3.9-4.2
. pH	(-)	6.9- 7.1	6.7-6.9	7.0
. temperature	(°C)	24 -27	26 -27	27
- aerated water				
. oxygen	(mg/l)	8.1- 9.2	-	-
. pH	(-)	7.1- 7.4	7.1- 7.2	7.5-7.7
. turbidity	(NTU)	6.9-10.0	24 -39	28 -38
- filtered water				
. total iron	(mg/l)	0.16-0.50(0.3)*	0.04-0.09	0.04-0.09
. ferrous iron	(mg/l)	< 0.02	< 0.02	< 0.02
. turbidity	(NTU)	1.3 - 4.8(3.0)*	0.4 -0.8	0.5- 1.0
. pH	(-)	7.2-7.5	7.0-7.2	7.3
. oxygen	(mg/l)	8.8 - 9.8	-	-
. residual chlorine	(mg/L)	0.2 - 0.6	-	-
- filter run length	(h)	15-17	9 -11	16 -17
- bed height		1.50	1.65	1.60
- grain size	(mm)	1.2- 1.5	1.2- 1.5	1,2- 1.5
- overflow height (above top filterbed)	(m)	1.65	1.80	1.40

* average values

Table 4.3. - Summary of backwash results

Parameter	Unit	Habiganj	Serajganj	Gopalganj
- filter surface	(m^2)	13.6	13.6	9.3
- back wash flow	(m^3/h)	533	508	342
- back wash rate*	(m/h)	39.2	37.4	36.8
- back wash time	(min)	13-15	15-17	13-15
- run time filter	(h)	15-17	9-11	16-17
- back wash frequency	(1/day)	1	1	1
- back wash water . consumption		125	135	80

* at this back wash rate no bed expansion occurs (0% at <42 m/h)

The water quality of some taps at Serajganj and Gopalganj is presented in appendix 6 and 7 respectively. The iron concentrations are below 0.11 mg/l and 0.07 mg/l respectively which is very good. Only at Maroarypatty in Serajganj the distribution line has to be flushed because of a rather high iron concentration of 0.74 mg/l.
Manganese is removed very well in Serajganj from 1.4 mg/l below 0.03 mg/l according to appendix 8.

No bleaching powder is dosed in Serajganj and Gopalganj and so is expected in Habiganj.
Reasons for this are:

- the tap samples of Serajganj and Gopalganj usually contain no coli bacteria according to the Zonal Laboratories of Rashahi and Kulna. A copy of a water analysis report of Serajganj in appendix 8 shows this.
- the expenses on electricity, salaries of employed people and small maintenance activities balance the income on consumer contributions. No money is left for the relatively expensive bleaching powder.

4.4. AERATOR AND FILTER PERFORMANCE

The aerators are working well in the three towns because the ferrous concentration in the aerated water is below 0.02 mg/l. The water distribution over the whole length of the weirs and falling of the water into the gutters is good, the temperature above 24°C and the pH above 6.9 so that all conditions for a rapid iron oxidation are fulfilled
The oxygen concentration has risen from < 1.0 mg/l to 8.1-9.2 mg/l in the aerated water and to 8.8-9.8 mg/l in the filtered water of Habiganj. The small concentration increase is caused by the aeration at the falling of the water in the clear water reservoir.
The filters also perform well in the three towns. The results are graphically presented in appendix 5, 6 and 7 and summarized in table 4.2. The filtered water quality is very good as discussed before and the filter run length corresponds rather well with the results of the filter model calculations (table 8, page 23 O and M Habiganj, in this table the filter run length at 128 m^3/h and 7 mg/l suspended solids must be 12 hours instead of 22).
The filter bed is designed in such a way that the overflow level is below the water level of breakthrough, so that filtered water quality is guaranteed During the trial runs at Habiganj the overflow pipes were closed so that an overflow level of 2.20 m instead of 1.70 m was reached after 20-25 hours filter run time. No break through occurred, only a slight increase of the iron concentration after 20 hours. These observations show that operation in practise corresponds well with theoretical predictions.

The filter run length in Serajganj was considerably shorter than in the other towns, which is caused by the considerably higher iron concentrations.

In Gopalganj the first filter runs were very short only 3-4 hours. This was caused by not or too short back washing. The filter sand turned to be sticky and slimy. After thorough back washing (three times after each other) the filterbeds were clean and normal filter run times were realised.

Filter sand was found in the filterdrain outlet of filter 1 in Serajganj. Removal of the sand bed showed that 7 nozzles were not fixed well and 1 was broken. After fixing, replacing and control of the other nozzles the sand was put back in the filter box and operation continued.

The filter bed height in Serajganj and Gopalganj has grown with 15 and 10 cm respectively. This is caused by the formation of a sediment layer around the sand grains. Dissolving of a filter sand sample in strong hydrochloric acid showed small air bubbles and yellow-brown colouring of the acid and in the case of Serajganj dark brown colouring.

The sediment layer is most probably a mixture of $CaCO_3$ and Fe_2O_3 - $Fe(OH)_3$ and in the case of Serajganj also MnO_2. The sediment layer dissolved completely and only in the case of Serajganj part of the sand surface remained black most probably with MnO_2. This sediment layer has a positive influence on the iron removal and serves as a catalytic surface for the manganese oxidation and removal. The experiment also showed that large amounts of strong hydrochloric acid will be required for dissolving the inorganic material at well regeneration.

4.5. BACK WASHING AND WASH WATER DISCHARGE

After 15 minutes back washing with a back wash rate of 37-39 m/h the filters in the three towns were completely clean and the turbidity in the wash water has dropped below 7 NTU (summary back wash data table 4.3.). Only in Serajganj back wash times are a few minutes longer. No mudballs were observed and no sand was found in the back wash gutter.

It can be concluded that the applied back wash operation in the three towns is performing well.

Calculations with DHV's EXPANSI PROGRAMME show that at the applied conditions no bed expansion occurs. Even better results are obtained at bed expansions of 1% or 2% at back wash rates in this case of respectively 42 or 45 m/h. This small bed expansion causes scouring of the sand grains and results in a better and quicker cleaning and it decreases the chance on mudball forming even more. A 10-15% increase of the back wash rate is necessary. This can be realised by removing the back wash orifice. Back wash times can be several minutes shorter so that the same back wash water volume is required.

The wash water in Gopalganj is discharged into the river running closely besides the plant. No extra facilities are required.

In Habiganj and Serajganj the wash water is discharged in rivers at a distance from the plant of 1.4 km and 0.85 km respectively. The wash water flows by gravity from the back wash gutter into the sludge tank with a volume of 125 m^3 and 146 m^3 respectively in the cases of Habiganj and Serajganj. In Serajganj the flow starts after the air has escaped from the transport pipe (to the sludge tank) and the back wash water level in the filters has almost reached the overflow level (1 80 m). In Habiganj the sludge tank is situated closer to the plant and the resistance in the transport pipe is much smaller so that the level rise of the back wash water is less than 0.5 m. The situation in Serajganj is not ideal and requires reduction of the resistance of the transport pipe in order to.

- improve the removal of dirty wash water above the filter to reduce back wash time
- improve the back wash rate

This can be realised by lifting the underground transport pipe to an overground exactly horizontal position (so no vertical parts).

Wash water transport from the sludge tank to the river is in Habiganj performed by a sludge pump (capacity 130 m^3/h) and in Serajganj by gravity. In both cases 150 mm PVC pipes are used. The wash water velocity in the transport pipe of Habiganj is 2.0 m/s so that no sedimentation and clogging problems are expected. In Serajganj the water velocity is lower so that sedimentation can occur and clogging belongs to the possibilities. If in the course of time pipe resistance increases the pipe has to be flushed. This has to be made carefully to prevent blowing up of the pipe. If frequent flushing turns out to be necessary it is advised to install a sludge pump with a capacity of 135 m^3/h.

Table 4.4. - Operation Iron Removal Plants

	Habiganj	Serajganj	Gopalganj
- division chamber			
. functioning of sliding notches	yes	yes	yes
. calibration measuring scales	correct	correct	correct
- aerators			
. equal water distribution	yes	yes	yes
. aeration	good	good	good
- filter			
. bed height (m)	1.50	1.65	1.60
. presence of mud balls	no	no	no
. equal distribution of sand on top of filterbed	yes	yes	yes
. equal distribution of wash water	yes	yes	yes
. presence of sand in back wash gutter	no	no	no
. presence of sand in drainage water	no	no	no
- chlorination in use	yes	no	no
- functioning of:			
. circuit breakers	yes	yes	yes
. on/off switches	yes	yes	yes
. control lamps	yes	yes	not all
. Volt and Ampère meters	yes	yes	yes
. hour counters HLP 1	0	1416	1379
. hour counters HLP 2	0	1223	1678
. HLP 1 high lifting (m^3/h)	236	212	200
. HLP 2 high lifting (m^3/h)	239	-	200
. HLP 1 back washing (m^3/h)	532	508	342
. HLP 2 back washing (m^3/h)	534	-	345
. pressure gauges pumps	yes	yes	yes
. low level cut out device	yes	yes	yes
. high water alarm C.W.R.	yes	yes	yes
. level indicator C.W.R.	yes	yes	yes
. level indicator O.H.T.	yes	yes	yes
. overflow of filters	no	yes	yes
. overflow of C.W.R.	yes	yes	yes
. drain division chamber	yes	yes	yes
. valves inside I.R.P.	yes	yes	yes
. drain filters	yes	yes	yes
. drain C.W.R.	yes	yes	yes

4.6. OPERATION AND MAINTENANCE

The state of operation and maintenance of the three plants is presented in table 4.4. and 4.5. The IRP in Habiganj was operated by the contractor in cooperation with the local consultant. Due to the fact that the Super Intendent was only partly and the operators were not present despite repeated invitations the introductory training could only partly be carried out (appendix 9). A thorough theoretical and practical training will be provided by the local consultant. After handing over the operation of the IRP to the Super Intendent and the operators it is advised to control occasionally the proper operation and maintenance. Financial problems for the operation and maintenance are not expected because income balances the expenses (appendix 10).

The operation and maintenance of the IRP in Serajganj is very good. The way of operation is as follows:
- 5.00 start production, fill clear water reservoir
- 5.45 start high lift pumps to fill overhead tank
- 6.45- 9.30 delivery to distribution net from overhead tank and clean water tank
- 12.00-14.00 delivery to distribution net
- 13.00 stop production and back wash filters
- 16.30-18.30 delivery from overhead tank to distribution net?

On the basis of the hour counters of the wells (± 2700 h) and the period of operation (January 1991-May 1992 = 16 months) the daily production is approximately only 6 hours. The hour counters of the high lift pumps total approximately 2600 h so that can be concluded that the overhead tank is intensively used for water supply (about 10% of the time the pumps are used for back washing).

The plant in Serajganj was operating trouble free until now according to the logbook and the operators. The following things can be improved:
1. Back wash water discharge to the sludge tank by lifting the transport pipe to an overground position
2. To prevent future problems with back wash water transport from the sludge tank to the river it is advised to install a sludge pump of 135m³/h.
3. Because of the rather strong smell of the toxic H_2S (rotten egg smell) escaping from the groundwater it is advised to improve the aeration above each filter with a fan with a shaft length of 1.0 m.
4. During the performance test lift pump 2 stopped to work. The pump and pump motor are in good condition. Most probably the problem is somewhere in the control panels. This will be soon repaired.

Point of attention for the Sub Divisional Engineer, Superintendent and Operators is that the logbook should be filled in more accurate.

The well performance and the state of operation and maintenance of the IRP in Gopalganj is poor. The water production is too small so that only one filter can be operated. The way of operation is comparable with that in Serajganj with the difference that the production is 16 hours instead of 8 hours. Back washing is not always carried out so that filter runs are short: only 3-4 hours. Normal filter runs of 13-15 hours could be realized at three times after each other back washing.
No or almost no maintenance has been carried out with the result that:
- the high lift pump motors are very noisy and strongly vibrate. The vibrations can be felt in the entire IRP building. The pump motors need urgently lubrication
- some control lamps and fuses are broken or missing
- almost all metal parts (pipes, valves, gratings, stairs and platform) are corroding and need urgently to be painted
- the logbook is not filled in

The knowledge of the new superintendent and the operators is poor. It is advised to let the training in Habiganj attend by the people of Gopalganj.

Table 4.5. - Maintence Iron Removal Plants

	Habinganj	Serajganj	Gopalganj
- state of:			
. intake system	good	good	good
. division chamber	good	good	dirty
. cascades	good	good	good
. filterbox	good	good	good
. clear water tank	clean	clean	clean
. over head tank	clean	clean	- *
. IRP building	good	good	good
- corrosion on:			
. gratings (division chamber)	no	yes	yes
. stairs, platform	no	no	yes
. pipes inside IRP	no	no	yes
. pipes outside IRP	no	no	no
. valves inside IRP	no	no	yes
. valves outside IRP	no	no	no
- leakage of:			
. pipes inside IRP	no	no	no
. pipes outside IRP	minor	minor	minor
. valves inside IRP	no	no	some
. valves outside IRP	no	no	no
- lubrication of:			
. pump motors	yes	yes	no
. valves	yes	yes	no
- control panels:			
. presence of fuses	all	all	not all
. presence of control lamps	all	all	not all

* because of the presence of several bee nests in the supporting construction climbing of the overhead tank was not recommended

5. CONCLUSIONS AND RECOMMENDATIONS

In this chapter the conclusions and recommendations are drawn and the proposed actions for the next period are given.

The overall conclusion is that the Iron Removal Plants are constructed very well and produce a very good filtered water quality. Operation and Maintenance is also very good possible in Bangladesh for example in Serajganj, but is a point of attention in Gopalganj and most probably also the first few months in Habiganj.

Below the conclusions are listed more specifically:

- The quality of construction (civil, mechanical and electrical works) of the plant in Habiganj is very high and so is the finishing touch.
- The state of operation and maintenance in Serajganj is very good. The filtered water quality is also very good (below 0.1 mg/l, the maximum desirable concentration of the World Health Organization).
- The well performance and also the operation and maintenance in Gopalganj is poor. The filtered water quality is very good.

- The operation and maintenance of the wells in the three towns is good. Only in Gopalganj two packings have to be replaced.
- In Habiganj sufficient overcapacity is present. In Serajganj no overcapacity is present and in Gopalganj only half the capacity is available.
- Large amounts of iron containing sediments were discharged during flushing of the distribution system in Habiganj.
- A jar test for the determination of the chlorine dosing showed that 6 mg/l bleaching powder has to be dosed in Habiganj.
- The free residual chlorine concentration at 6 taps was between 0.2 and 0.6 mg/l.
  The iron concentration at these tap samples was below 0.22 mg/l.
- The water quality of the taps in Serajganj and Gopalganj is also very good.
- In Serajganj and Gopalganj no bleaching powder is dosed. Reasons for this are the fact that according to the Zonal Laboratories the water does not contain coli bacteria and the fact that no money is left for the relatively expensive bleaching powder.
- Manganese is also removed very well in Serajganj from 1 4 mg/l below 0.03 mg/l.
- The cascade aerators are performing well in the three towns because the ferrous concentration in the aerated water is below 0.02 mg/l.
- The filters perform well in the three towns. Filter runs of 9-11 hours are obtained in Serajganj with an iron concentration in the raw water of 7.3 mg/l In Habiganj and Gopalganj the filter run length is 15-17 hours at an iron concentration of respectively 3 3 - 3.9 mg/l.
- After 15 minutes backwashing at a backwash rate of 37-39 mg/h the filters in the three towns were completely clean. No mudballs were observed. It is expected that at slightly higher backwash rates and shorter backwash times even betters results will be obtained.
- The backwash water discharge in Habiganj and Gopalganj operates without problems. In Serajganj some changes should be carried out.

The recommendations and proposed actions for the next period are listed below:

Habiganj

- Reparation of the pump, pump motor and foundation of well 1.
- Translation of Operation and Maintenance Manual and Logbook in Bengali and supply to Super Intendent and operators.
- Provision of a theoretical and practical training for the Super Intendent and operators. The training material and papers of Gopalganj can be used.
- Control of the Operation and Maintenance of the plant, the recordings in the Logbook and the knowledge of the Super Intendent after a few months.

Serajganj

- It is recommended to increase the potential well capacity for example by connecting well 4 and 5 to the IRP, so that some overcapacity is directly available.
- To prevent future problems with the backwash water discharge to the sludge tank the transport pipe should be lifted to an overground exactly horizontal position.
- If frequent flushing of the backwash water transport pipe from the sludge tank to the river turns out to be necessary a 135 m^3/h sludge pump should be installed.
- Fixing a fan with a shaft length of 1.0 m above each filter.
- Reparation of the control system of high lift pump 2
- Checking the recordings in the Logbook after a few months.
- Painting corroded parts (for example the gratings in the division chamber).
- Removing backwash orifice to obtain bigger back wash flow.

Gopalganj

- Urgently increasing well capacity by regenerating existing wells, connecting well 4 and 5 to the IRP if possible and sinking new wells.
- Repairing leakages at existing wells and valves inside IRP.
- Urgently improving Operation and Maintenance of the treatment plant.
  The Super Intendent should study the Operation and Maintenance Manual. After a few months the Operation and Maintenance of the plant should be checked, the recording in the Logbook and also the knowledge of the Super Intendent.
- Urgently lubricating the high lift pump motors and valves (all bearings).
- Urgently replacing broken control lamps and missing fuses by new ones.
- Urgently removing the corrosion from corroded parts and paint them (pipes, valves, gratings, stairs and platform).
- Removing back wash orifice for bigger back wash flow.
- Cleaning of division chamber. The bacterial slime layer should be removed to prevent bacterial infections of the IRP and distribution system. Disinfection of the whole IRP and distribution system would require large amounts of bleaching powder.

Appendix 1: List of relevant items required for start up

I. Analytic instruments (incl. documentation) and calibration standards for measurement of the water quality variables

Analytic Instrument	Calibration standard(s)
Turbidimeter	1, 10 and 100 NTU
Iron analyzer (photometer)	
Chlorine analyzer	
Thermometer	
E-coli sample bottles	
Oxygen meter	Zero Standard (sodiumphosphate)
pH meter	pH =4, pH - 7 buffer solutions

II. Other requirements for measurements

- jar test apparatus
- filtering paper
- 6 beakers (1000 ml)
- balance (0-5 kg)
- balance (0-20 kg)
- measuring cylinders (500, 1000, 2000 ml)
- baumé density meter
- 25 semple bottles (glass, 1 litre)
- 25 sample bottles (plastic, 1 litre)
- one funnel
- 2 no. 10. Sieves (0.5 m^2)
- 2 no. 16 Sieves (0.5 m^2)
- 20 litre distilled water (iron free)
- stopwatch
- 10 litre bucket

III. Item for handling bleaching powder

- safety glasses
- plastic gloves
- rubber apron

IV. Stock chemicals

- 250 kg bleaching powder

Appendix 2: Blank forms for trial run

FORM 1 : FILTERBED MATERIAL

Operator : ....
Date : .....
Nr. filterbed : ....

	FILTERBERBED MATERIAL			
Sample no.	Sample size (kg)	Fraction < .. mm (kg)	Fraction > .. mm (kg)	Remarks

FORM 2 : CASCADE AERATORS

Operator :
Trial run nr. : ..
Date : .....
Cascadenr. : .....

	RAW WATER				FILTER INFLUENT				
Time (hr:min)	Flow (m3/hr)	Tempera-ture (oC)	Oxygen (mg/l)	pH	Oxygen (mg/l)	pH	Fe2+ (mg/l)	Fetot (mg/l)	Remarks

Note : Fe2+ = soluble ferrous compounds
. Fetot = total iron concentration

FORM 3 : FILTERS

Operator :
Trial run nr. : ..
Date : .....
Filternr. : .....

	INFLUENT			FILTER	EFFLUENT		
Time (hr:min)	Flow (m3/hr)	Fetot (mg/l)	Turbidity (NTU)	Headloss (m)	Fetot (mg/l)	Turbidity (NTU)	Remarks

FORM 4 : BACKWASHING OF FILTERS

Operator :
Trial run nr. : ..
Date : .....
Filternr. : .....

bed height before backwashing : .... m
bed height during backwashing : .... . m
bed height after backwashing : .... .. m
filtermaterial lost during backwashing : yes/no

	PUMP		BACKWASH DISCHARGE	
Time (hr:min)	Pump head (m)	Backwash flow (m3/hr)	Turbidity (ntu)	Remarks

FORM 5 : CHLORINATION UNIT

Operator :
Trial run nr. : ..
Date : .....
Location taps of distribution network :

tap 1 .....
tap 2 .....
tap 3 .....
tap 4 .....

	RAW WATER	BLEACHING POWDER	RESIDUAL CHLORINE (mg/l)				
Time (hr:min)	Flow (m3/hr)	Solution strength (%)	Dosing flow (ml/s)	Tap 1	Tap 2	Tap 3	Tap 4	Remarks

FORM 6 : IRON CONCENTRATION IN DISTRIBUTION NETWORK

Operator :
Trial run nr. : ..
Date : .....
Location taps of distribution network :
tap 1 .....
tap 2 .....
tap 3 .....
tap 4 .....

	RAW WATER	IRON (mg/l)				
Time (hr:min)	Flow (m3/hr)	Tap 1	Tap 2	Tap 3	Tap 4	Remarks

FORM 7 : E-COLI IN DISTRIBUTION NETWORK

Operator :
Trial run nr. : ..
Date : .....
Location taps of distribution network :
tap 1 .....
tap 2 .....
tap 3 .....
tap 4 .....

	RAW WATER	E-COLI				
Time (hr:min)	Flow (m3/hr)	Tap 1	Tap 2	Tap 3	Tap 4	Remarks

Appendix 3: Jar test bleaching powder dose

1. Make up 3.00 g bleaching powder in 1.00 l filtered water (shake well). The active chlorine concentration is approximately 1.0 g/l

2. Clean four 1.000 ml beakers
   Fill each beaker with 500 ml filtered water

3. Add the following amounts of 1.00 g/l active chlorine solution to the four beakers
   (Filtered water quality: total iron 0.4 mg/l, turbidity 3.5 NTU)

- Beaker	1	2	3	4	5
- required active chlorine concentration (mg/l)	1	3	5	7	9
- ml bleaching powder solution (1.00 g/l)	0.50	1.50	2.50	3.50	4.5
Measured free chlorine	< 0.1	< 0.2	0.4	0.6	1.5

4. Keep the beakers in a dark place
   Stir each of the beakers 30 minutes by hand

5. Wait 15 mintues (reaction time)
   Keep the beakers in a dark place

6. Determine in each beaker the residual free chlorine with the test kit

Appendix 4 - Sieve analysis filter sand

DUTCH ASSISTED WATER SUPPLY, SANITATION AND DRAINAGE PROJECTS
PROJECT NAME : 12 DTP

PARTICLE SIZE ANALYSIS

SAMPLE COLLECTED : Mr. A.K.M.Abdus Satter, Sr. WS Engineer
& Mr. Jahangir Alamn, SDE DPHE Habigonj
LOCATION : Filter sand for IRP Habigonj
DATE OF TEST : 30th April, 1992
SAMPLE NUMBER : Two times sieving and washing
TESTED AT : Sylhet Polytechnic Institute

SIEVE ANALYSIS

SIEVE NUMBER no	SLOT SIZE mm	MATERIALS RETAINED gm	MATERIALS RETAINED %	CUMULATATIVE RETAINED %	FINER %
04	4.760	0.000	0.000	0.000	100.000
08	2.362	0.700	0.070	0.070	99.930
10	1.700	14.900	1.493	1.564	98.436
14	1.180	917.900	92.002	93.565	6.435
16	0.991	0.000	0.000	93.565	6.435
20	0.833	0.000	0.000	93.565	6.435
28	0.600	62.200	6.234	99.800	0.200
35	0.417	0.000	0.000	99.800	0.200
PAN	0.000	2.000	0.200	100.000	(0.0000)
TOTAL		997.700	100.000		

RESULTS:-

a. Uniformity Coefficient:-

D10 = 1.25 mm D60 = 1.45 mm Uniformity Coefficient, U = 1.16

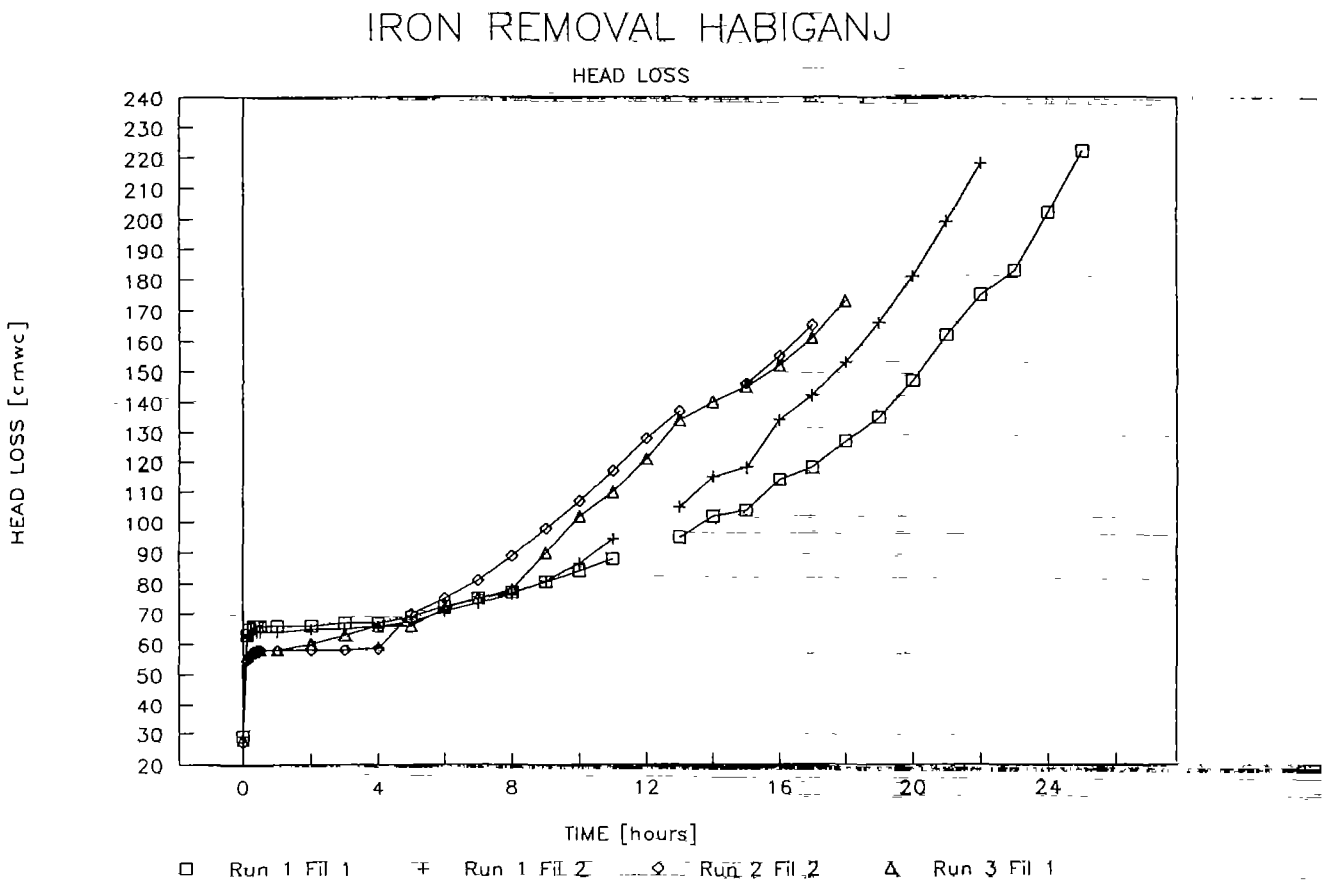
b. Grain Size Distribution:-

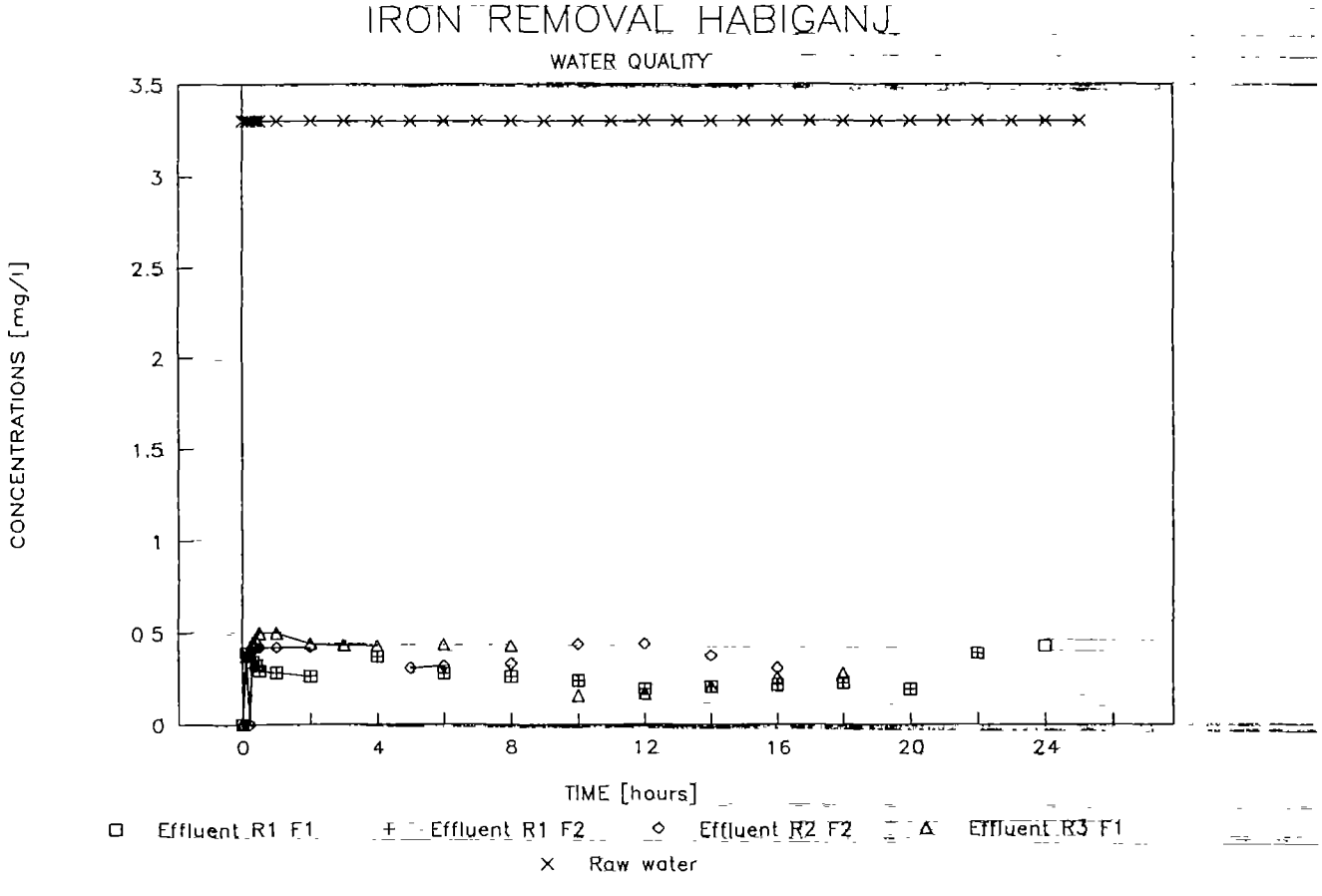
Grain size range in mm	*% materials*
2.50 to 2.00	*01.00*
2.00 to 1.65	*01.00*
1.65 to 1.50	*07.50*
1.50 to 1.20	*82.00*
1.20 to 1.00	*03.50*
1.00 to 0.00	*04.50*

RECOMMENDATION:-

As the percentage of sand size lower than 1.20 mm is 8.00 percent, so the filter sand sample can be used as a filter sand for the IRP Habigonj.

Appendix 5 - Data trial runs Habiganj





TRIAL RUNS HABIGANJ WATER QUALITY

Date	Time [h]	RAW WATER Temperatu [C]	RAW WATER pH [-]	RAW WATER Oxygen [mg/l]	RAW WATER Turbidity [NTU]	RAW WATER Total Iron [mg/l]	AERATED WATER Temperatu [C]	AERATED WATER pH [-]	AERATED WATER Oxygen [mg/l]	AERATED WATER Turbidity [NTU]	AERATED WATER Total Iron [mg/l]
18-05-'92	03.00	25.0	6.9	3.8	-	3.4	25.0	7.3	8.1	6.9	3.4
18-05-'92	09.00	24.5	-	3.8	-	2.9	24.5	-	8.8	8.4	2.9
18-05-'92	15.00	-	6.9	-	-	3.1	-	7.3	-	-	3.0
18-05-'92	21.00	27 0	6.9	3.6	-	2 9	27.0	7.3	8.4	8.8	2.8
19-05-'92	03.00	-	-	-	-	4.2	25.0	7.4	8.8	9.5	3.5
19-05-'92	18.00	25.0	7.0	3.3	-	3.4	25.0	7.3	7.8	9.0	2.9
19-05-'92	00.00	25.0	6.9	3.0	-	3.1	25.0	7.2	9.2	9.5	3 1
20-05-'92	06.00	24.0	6.7	-	-	3.3	-	7.2	-	-	-
20-05-'92	12.30	25.0	6.9	-	-	3.3	25.0	7.2	-	8.5	3.2
20-05-'92	19.30	25.0	6.9	-	-	3.3	25.0	7.3	-	9.0	3 1
20-05-'92	22.30	25.0	6.9	-	-	3.3	25.0	7.2	-	8.5	3.3
21-05-'92	06.30	25.0	7.1	-	-	3.3	25.0	7.1	-	10.0	3.3

BACK WASH DATA HABIGANJ

TIME [min]	TURBIDITY [NTU] Run 1 Fil 2	TURBIDITY [NTU] Run 2 Fil 2	TURBIDITY [NTU] Run 3 Fil 1
1	-	150	170
3	-	120	100
5	39	32	45
7	17	18	20
9	16	15	12
11	11	12	3.5
13	10	7.5	2.8
15	7.5	6.5	2
17	7	5.5	1.5
19	6.8	5	1.5
21	6.5	5	-
23	6.5	-	-

WATER QUALITY TAPS HABIGANJ
Condition: chlorine dosing

TAP NO.	LOCATION	TURBIDITY [NTU]	pH [-]	CHLORINE [mg/l]	TOTAL IRON [mg/l]
1	IRP area	2.3	7 6	0.6	0.22
2	Police Station	35	7.4	0.2	5.3
3	Govt. Girls school	1.5	7.4	0.3	0.13
4	Bazar	1.8	7.5	0.2	0.18
5	Sanker Bachraloy road	2	7.4	0.2	0.19
6	Hotel Siraji	1.3	7.5	0.2	0.09

TRIAL RUN 1 HABIGANJ

Data: Date: 18-05-1992
Filter in operation: Number 1
Temperature: 24-27 C
Running time: 24 hours
Notes: Filteroverflow closed

Time	Flow	Head loss	Filtered water		Filtered water		Remarks
			pH	Oxygen	Turbidity	Total Iron	
[h]	[m3/h]	[cmwc]	[-]	[mg/l]	[NTU]	[mg/l]	
0	102	29					start at 03.00 am
.10	102	63	7.5	8.5	3.1	.39	
.20	102	65			2.5	.37	
.30	102	66			2.45	.34	
.40	102	66			2.4	.32	
.50	102	66			2.4	.29	
1.0	102	66			2.3	.28	
2.0	102	66	7.5	8.3	2.2	.26	
3.0	102	67					
4.0	102	67	7.5	9.8	2.2	.37	
5.0	102	69					
6.0	102	72.5		9.2	2.2	.28	
7.0	102	75					
8.0	108	77		9.4		.26	
9.0	108	80.5					
10.0	102	84		9.4	2.5	.24	
11.0	102	88					power failure for 43 min
12.0	102				2.7	.19	power failure for 7 min
13.0	102	94					power failure for 4 min
14.0	108	107		9.4	2.4	.21	power failure for 5 min
15.0	102	104					
16.0	102	114	7.5	8.8	2.6	.22	
17.0	102	118					
18.0	102	127	7.5	9.2	3.2	.23	
19.0	102	135					
20.0	102	147			2.5	.19	
21.0	102	162					
22.0	102	175			4.6	.39	
23.0	102	183					
24.0	102	202			4.8	.43	
25.0	102	222					stop at 04.00 am (overflow)

TRIAL RUN 1 HABIGANJ

Data: Date: 18-05-1992
Filter in operation: Number 2
Temperature: 24-27 C
Running time: 21 hours
Notes: Filteroverflow closed

Time	Flow	Head loss	Filtered water		Filtered water		Remarks
			pH	Oxygen	Turbidity	Total Iron	
[h]	[m3/h]	[cmwc]	[-]	[mg/l]	[NTU]	[mg/l]	
0	102	29					start at 03.00 am
.10	102	62	7.5	8.5	3.1	.39	
.20	102	63.5			2.5	.37	
.30	102	64			2.45	.34	
.40	102	64			2.4	.32	
.50	102	64			2.4	.29	
1.0	102	64			2.3	.28	
2.0	102	65	7.5	8.3	2.2	.26	
3.0	102	65					
4.0	102	66	7.5	9.8	2.2	.37	
5.0	102	67.5					
6.0	102	71		9.2	2.2	.28	
7.0	102	73.5					
8.0	108	76.5		9.4		.26	
9.0	108	81					
10.0	108	86.5		9.4	2.5	.24	
11.0	108	94.5					power failure for 43 min
12.0	108				2.7	.19	power failure for 7 min
13.0	108	104					power failure for 4 min
14.0	108	115		9.4	2.4	.21	power failure for 5 min
15.0	108	118					
16.0	102	134	7.5	8.8	2.6	.22	
17.0	102	142					
18.0	102	153	7.5	9.2	3.2	.23	
19.0	102	166					
20.0	102	181			2.5	.19	
21.0	102	199					
22.0	102	218			4.6	.39	stop at 01.00 am (overflow)

TRIAL RUN 2 HABIGANJ

Data: Date: 19-05-1992
Filter in operation: Number 2
Temperature: 24-27 C
Running time: 15 hours
Notes: Filteroverflow closed

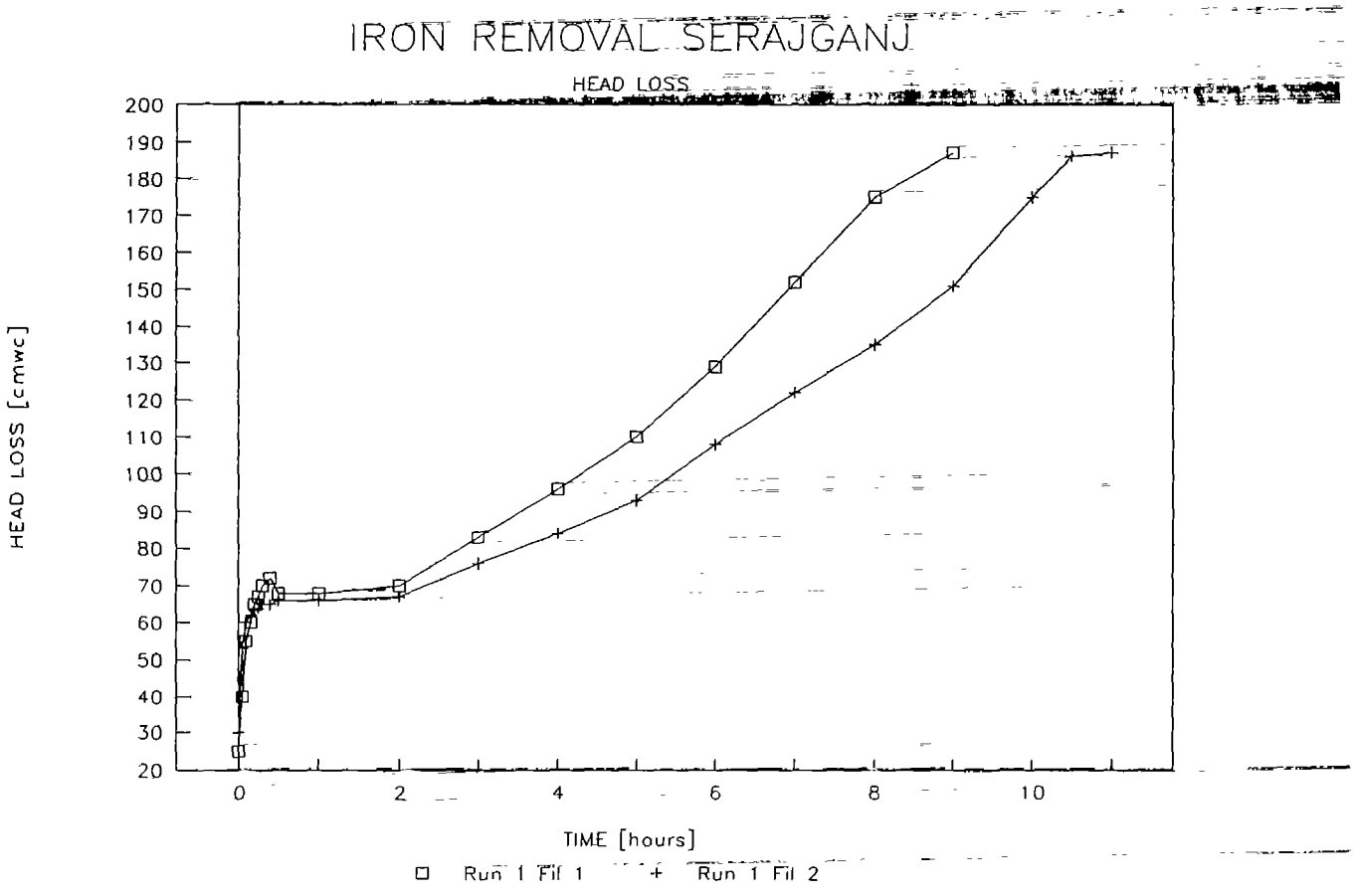
Time	Flow	Head loss	Filtered water		Filtered water		Remarks
			pH	Oxygen	Turbidity	Total Iron	
[h]	[m3/h]	[cmwc]	[-]	[mg/l]	[NTU]	[mg/l]	
0	102	27					start at 06.00 pm
.10	102	54.5	7.4		3.0	.37	
.20	102	56			3.5		
.30	102	57.5			3.5	.42	
.40	102	58			3.5	.42	
.50	102	58			3.5	.42	
1.0	102	58			3.5	.42	
2.0	102	58	7.4	8.0	3.5	.42	
3.0	102	58			2.5		
4.0	102	58.5					power failure for 32 min
5.0	102	70	7.4	9.0	2.6	.31	
6.0	102	75	7.4	8.8	3.0	.32	
7.0	102	81					
8.0	102	89	7.3		3.5	.33	
9.0	102	98					
10.0	102	107	7.4		3.8	.44	
11.0	102	117					
12.0	102	128	7.2		4.5	.44	
13.0	102	137					
14.0	102		7.2	9.0	4.0	.38	power failure for 88 min
15.0	102	146					
16.0	102	155	7.5		3.5	.31	
17.0	102	165					stop at 11.00 am (overflow)

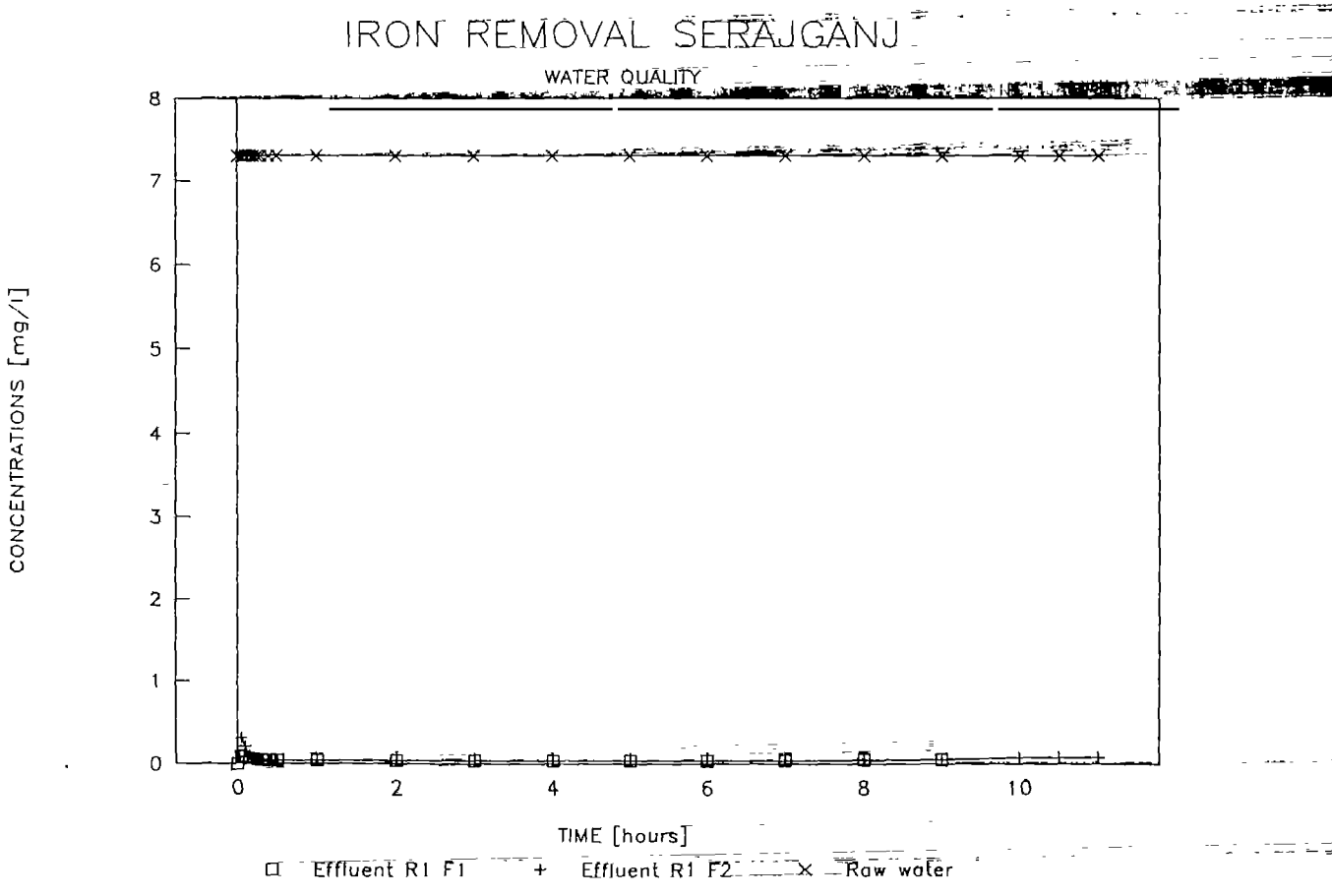
TRIAL RUN 3 HABIGANJ

Data: Date: 20-05-1992
Filter in operation: Number 1
Temperature: 24-27 C
Running time: 17 hours
Notes: Filteroverflow closed
Oxygen meter defect

Time	Flow	Head loss	Filtered water		Filtered water		Remarks
			pH	Oxygen	Turbidity	Total Iron	
[h]	[m3/h]	[cmwc]	[-]	[mg/l]	[NTU]	[mg/l]	
0	102	28					start at 00.30 pm
.10	102	56			3.6	.37	
.20	102	57			3.4	.39	
.30	102	57.5			3.5	.45	
.40	102	58			4.0	.47	
.50	102	58	7.3		4.2	.50	
1.0	102	58	7.2		4.3	.50	
2.0	102	60	7.3		4.0	.44	
3.0	102	63	7.3		4.0	.43	
4.0	102	66	7.3		4.0	.43	power failure for 18 min
5.0	102	66					
6.0	102	72	7.3		4.0	.44	power failure for 32 min
7.0	102	75					power failure for 12 min
8.0	102	78	7.3		2.0	.43	
9.0	102	90					
10.0	102	102	7.3		1.7	.16	
11.0	102	110					power failure for 5 min
12.0	102	121			1.3	.17	
13.0	102	134					
14.0	102	140				.21	
15.0	102	145					power failure for 6 min
16.0	102	152				.26	
17.0	102	161					
18.0	102	173			2.6	.28	stop at 06.30 am (overflow)

Appendix 6 - Data performance tests Seraiganj





PERFORMANCE TESTS SERAJGANJ WATER QUALITY

Date	Time [h]	RAW WATER Temperatu [C]	pH [-]	RAW WATER Oxygen [mg/l]	RAW WATER Turbidity [NTU]	RAW WATER Total Iron [mg/l]	AERATED WATER Temperatu [C]	AERATED WATER pH [-]	AERATED WATER Oxygen [mg/l]	AERATED WATER Turbidity [NTU]	AERATED WATER Total Iron [mg/l]
24-05-'92	12.00	26.0	6.7	-	4.5	7.3	26.0	7 1	-	39	7.3
24-05-'92	15.00	27.0	6.7	-	.7	7.2	27.0	7.2	-	24	7.2
24-05-'92	18.00	27.0	6.9	-	3 5	7.3	27 0	7.1	-	34	7.3

BACK WASH DATA SERAJGANJ

TIME [min]	TURBIDITY [NTU] Run 1 Fil 2	TURBIDITY [NTU] Run 2 Fil 2
1	900	860
3	850	650
5	800	450
7	82	76
9	80	60
11	40	9.5
13	24	3.2
15	6	4
17	2	5
19	2	-
21	10	-
23	14	-

WATER QUALITY TAPS

TAP NO.	LOCATION	TURBIDITY [NTU]	pH [-]	CHLORINE [mg/l]	TOTAL IRON [mg/l]
1	Kalibari Compound	0.5	7.5	-	0.09
2	Maroarypatty (OHT 2)	5	7.8	-	0.74
3	Municipality Office	0.6	7.3	-	0.11
4	Hassanpur Yardconnection	0.4	7.4	-	0.09

PERFORMANCE TEST 1 SERAJGANJ

Data: Date: 24-05-1992
Filter in operation: Number 1
Temperature: 26-27 C
Running time: 9 hours
Notes: Filteroverflow closed
Oxygen meter defect

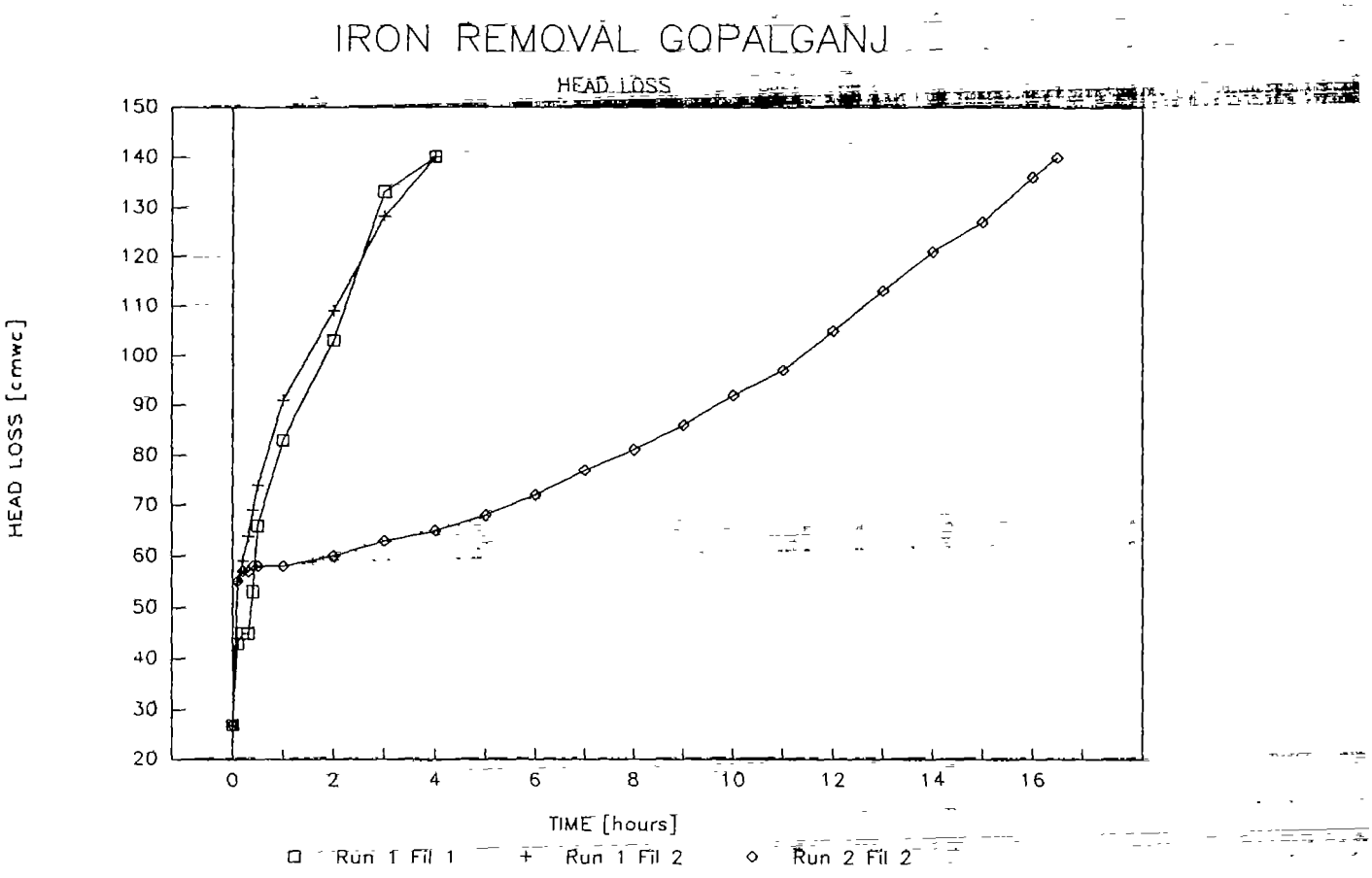
Time	Flow	Head loss	Filtered water		Filtered water		Remarks
			pH	Oxygen	Turbidity	Total Iron	
[h]	[m3/h]	[cmwc]	[-]	[mg/l]	[NTU]	[mg/l]	
0	108	25					start at 11.30 am
.05	108	40	7.0		0.7	.09	
.10	108	55	7.1		0.6	.07	
.15	108	60	7.1		0.5	.06	
.20	108	65	7.0		0.5	.06	
.25	108	67	6.9		0.4	.05	
.30	108	70	7.0		0.4	.05	
.40	108	72	7.2		0.4	.04	
.50	102	68	7.1		0.4	.04	
1.0	102	68	7.0		0.4	.04	
1.5	102	70	6.9		0.4	.04	
2.0	108	83	7.1		0.4	.04	
3.0	108	96	7.0		0.4	.04	
4.0	108	110	7.1		0.4	.04	
5.0	108	129	7.0		0.4	.04	
6.0	108	152	7.0		0.4	.04	
7.0	108	175	7.1		0.4	.05	
8.0	108	187	7.0		0.4	.05	stop at 7.30 pm

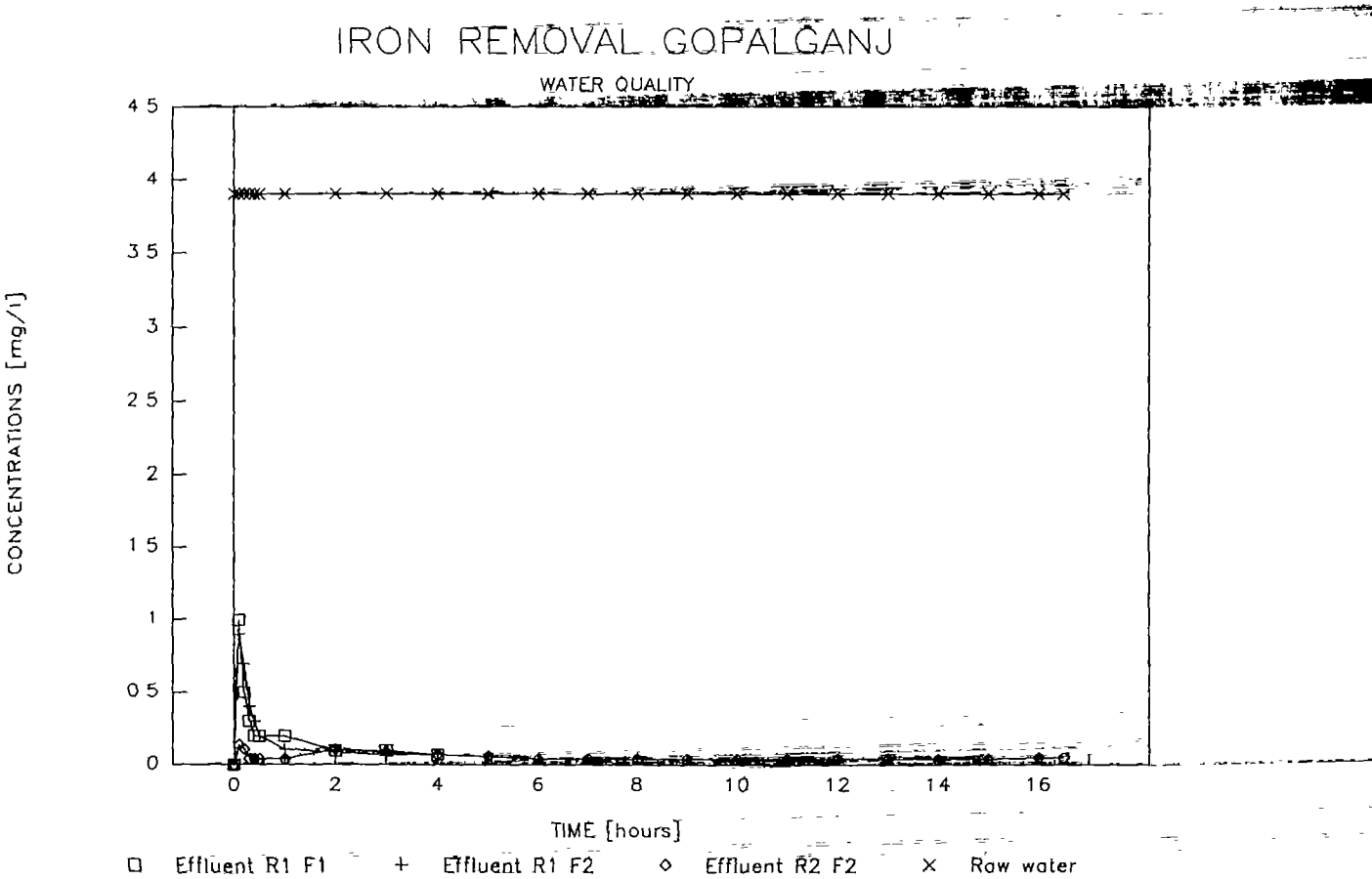
PERFORMANCE TEST 1 SERAJGANJ

Data: Date: 24-05-1992
Filter in operation: Number 2
Temperature: 26-27 C
Running time: 11 hours
Notes. Filteroverflow closed
Oxygen meter defect

Time	Flow	Head loss	Filtered water		Filtered water		Remarks
			pH	Oxygen	Turbidity	Total Iron	
[h]	[m3/h]	[cmwc]	[-]	[mg/l]	[NTU]	[mg/l]	
0	102	30					start at 02.30 am
.05	102	53	7.1		0.8	.3	
.10	102	60			0.7	0.2	
.15	102	62			0.7	0.1	
.20	102	64	7.0		0.6	0.07	
.25	102	64			0.6	0.06	
.30	102	65			0.5	0.05	
.40	102	65	7.1		0.5	0.04	
.50	102	66			0.4	0.04	
1.0	102	66	7.0		0.4	0.04	
2.0	102	67			0.4	0.04	
3.0	102	76			0.4	0.04	
4.0	102	84	7.1		0.4	0.04	
5.0	102	93			0.4	0.04	
6.0	102	108			0.4	0.04	
7.0	102	122	7.0		0.4	0.04	
8.0	108	135			0.4	0.04	
9.0	108	151			0.4	0.05	
10.0	108	175			0.6	0.07	
10.5	102	186	7.1		0.7	0.07	
11.0	102	187	7.5		0.8	0.07	stop at 9.30 pm

Appendix 7 - Data performance tests Gopalganj





PERFORMANCE TESTS GOPALGANJ WATER QUALITY

Date	Time [h]	RAW WATER Temperatu [C]	pH [-]	RAW WATER Oxygen [mg/l]	RAW WATER Turbidity [NTU]	RAW WATER Total Iron [mg/l]	AERATED WATER Temperatu [C]	pH [-]	AERATED WATER Oxygen [mg/l]	AERATED WATER Turbidity [NTU]	AERATED WATER Total Iron [mg/l]
26-05-'92	22.30	27.0	7.0	-	9	4.0	27.0	7.7	-	45	3.9
27-05-'92	10.00	27.0	7.0	-	8	4.0	27.0	7.5	-	38	3.9
27-05-'92	12.00	27.0	7.0	-	9	4.0	27.0	-	-	38	3.9
27-05-'92	16.00	27.0	7.0	-	9	3.9	27.0	7.6	-	31	3.8
27-05-'92	20.00	27.0	7.0	-	8	4.2	27.0	7.7	-	28	3.6
27-05-'92	24.00	27.0	7.0	-	8	4.1	27.0	7.5	-	32	3.9

BACK WASH DATA GOPALGANJ

TIME [min]	TURBIDITY [NTU] Run 2 Fil 2
1	460
3	420
5	400
7	100
9	20
11	3.5
13	1.8
15	1.6
17	1.6
19	1.6
21	1.6
23	1.6

WATER QUALITY TAPS GOPALGANJ

TAP NO.	LOCATION	TURBIDITY [NTU]	pH [-]	CHLORINE [mg/l]	TOTAL IRON [mg/l]
1	Mandertala	1.3	7.3	-	0.06
2	Post office	0.7	7.3	-	0.07
3	Cow market	0.5	7.3	-	0.06
4	Biswasbari road	0.4	7.3	-	0.06
5	DPHE Office	0.4	7.3	-	0.07

PERFORMANCE TEST 1 GOPALGANJ

Data: Date: 18-05-1992
Filter in operation: Number 1
Temperature: 26-27 C
Running time: 3.5 hours
Notes: Filteroverflow closed
Oxygenmeter defect

Time [h]	Flow [m3/h]	Head loss [cmwc]	Filtered water pH [-]	Filtered water Oxygen [mg/l]	Filtered water Turbidity [NTU]	Filtered water Total Iron [mg/l]	Remarks
0	37	27					start at 10.30 pm
.10	44	43	7.3		3.4	1.0	
.20	44	45	7.3		1.3	.5	
.30	44	45	7.3		0.7	.3	
.40	65	53	7.3		0.4	.2	
.50	66	66	7.3		0.4	.2	
1.0	66	83	7.3		0.4	.2	
2.0	65	103	7.3		0.5	.1	
3.0	65	133	7.3		0.5	.1	
3.5	65	140	7.3		0.5	.07	stop at 02.00 am (overflow)

PERFORMANCE TEST 1 GOPALGANJ

Data: Date: 18-05-1992
Filter in operation: Number 2
Temperature: 26-27 C
Running time: 4 hours
Notes: Filteroverflow closed
Oxygenmeter defect

Time [h]	Flow [m3/h]	Head loss [cmwc]	Filtered water pH [-]	Filtered water Oxygen [mg/l]	Filtered water Turbidity [NTU]	Filtered water Total Iron [mg/l]	Remarks
0	69	27					start at 04.00 am
.10	69	55	7.3		3.2	.9	
.20	69	59	7.3		2.1	.7	
.30	69	64	7.3		1.1	.4	
.40	69	69	7.3		0.8	.3	
.50	69	74	7.3		0.6	.2	
1.0	69	91	7.3		0.5	.11	
2.0	69	109	7.3		0.5	.09	
3.0	69	128	7.3		0.4	.07	
4.0	69	140	7.3		0.4	.07	stop at 08.00 am (overflow)

PERFORMANCE TEST 2 GOPALGANJ

Data: Date: 19-05-1992
Filter in operation: Number 2
Temperature: 26-27 C
Running time: 16.5 hours
Notes: Filteroverflow closed
Oxygenmeter defect

Time [h]	Flow [m3/h]	Head loss [cmwc]	Filtered water pH [-]	Filtered water Oxygen [mg/l]	Filtered water Turbidity [NTU]	Filtered water Total Iron [mg/l]	Remarks
0	69	27					start at 10.00 am
.10	69	55	7.3		1.3	.14	
.20	69	57	7.3		1.0	.11	
.30	69	57	7.3		0.7	.04	
.40	69	58	7.3		0.5	.04	
.50	69	58	7.3		0.5	.04	
1.0	69	58	7.3		0.5	.04	
2.0	69	60	7.3		1.3	.11	power failure for 5 min
3.0	69	63	7.3		0.8	.09	power failure for 4 min
4.0	69	65	7.3		0.6	.07	power failure for 3 min
5.0	69	68	7.3		0.6	.06	
6.0	69	72	7.3		0.5	.04	
7.0	69	77	7.3		0.5	.04	
8.0	69	81	7.3		0.6	.04	
9.0	69	86	7.3		0.6	.04	
10.0	69	92	7.3		0.6	.04	
11.0	69	97	7.3		0.6	.04	
12.0	69	105	7.3		0.6	.04	
13.0	69	113	7.3		0.6	.04	
14.0	69	121	7.3		0.6	.04	
15.0	69	127	7.3		0.6	.04	
16.0	69	136	7.3		0.7	.05	
16.5	69	140	7.3		0.7	.05	stop at 02.30 am (overflow)

Lab. No. :- 6
Dist./Thazilla :- Sirajganj
Mode of Transport :- Local Transport.

GOVERNMENT OF PEOPLE'S REPUBLIC OF BANGLADESH
PUBLIC HEALTH ENGINEERING, ZONAL LABORATORY
RAJSHAHI.

Date of Sampling :- 29.1.92
Date of Received in Lab :- 30.1.92
Date of Analysis :- 30.1.92
Sample Collected by :- md. Helaluddi

WATER ANALYSIS REPORT.

Location and Bottle No.	Source Code no.	Source	Temp. °C Field / Lab.	pH Field / Lab.	E.C. µScm	Turbidity (NTU)	D.O. mg/L	Cl mg/L	HCO_3 mg/L as Calcium	CO_2 mg/L	T.H. mg/L	Ca. H. mg/L	Mg. H. mg/L	Fe mg/L Field / Lab.	Mn mg/L	NH_3 mg/L	T.D.S. mg/L	Cl_2 mg/L	T. Coli N/100 ml. H_2O	F. Coli N/100 ml. H_2O	Remarks
Maternity & child health complex. main gate Road. Bottle no- 4	319	½" H/C	26 / 21	7·2 / 7·3	522	0·6	3·1	90	270	12	216	192	24	0·3 / 0·24	0·05	0·6	·	-	nil	-	0·2 K.m dist. from P/H.
Dhanlandhi treatment plant. Bottle no- 33	279	I.R.P.	26 / 21	6·8 / 6·6	561	63	2·9	75	260	11	216	192	24	7·7 / 7·66	1·39	0·7	-	-	nil	-	Before filter 1 K.m dist. from P/H
Dhanlandhi treatment plant Bottle no- 49	280	I.R.P.	26 / 21	7·7 / 7·8	542	0·6	2·8	60	270	11	216	192	24	0·1 / 0·09	0·03	0·2	-	-	nil	-	After filter 1 K.m dist. from P/H
Infront of Kalibari S.B Road. Bottle no- 3A	320	½" S/H	26 / 21	7·3 / 7·4	537	0·1	3·0	60	215	10	199	160	39	0·1 / 0·05	0·03	0·2	-	-	nil	-	1·2 K.m dist. from P/H.
Sirajganj Govt. College campus. Bottle no- 25	321	1½" H/Tw	26 / 21	6·8 / 6·7	1000	22	2·8	90	145	26	237	208	29	3·0 / 2·84	2·19	0·8	-	-	nil	-	
PHE. office Bottle no- 55	322	I.R.P.	26 / 21	7·1 / 7·2	234	1·6	2·9	60	155	10	147	128	19	0·4 / 0·39	0·08	0·6	-	-	nil	-	0·2 K.m dist. from P/H.
Suruchi Confectionery. K.B. Road. Bottle no- 26	241	½" H/C	26 / 21	7·3 / 7·3	1390	1	2·9	180	440	22	263	224	39	0·1 / 0·07	0·16	0·3	-	-	6 nos	✓	0·5 K.m dist. from P/H
PHE. I.B. Bottle no- 45	235	½" H/C	26 / 21	7·1 / 7·2	532	0·2	3·0	75	270	10	205	176	29	0·1 / 0·09	0·03	0·8	-	-	nil	-	0·2 K.m dist. from P/H.
S.D.E. PHE's residence PHE. Campus. Bottle no- 37	323	½" H/C	26 / 21	7·1 / 7·1	532	0·6	3·1	75	270	10	221	192	29	0·1 / 0·10	0·03	0·7	-	-	nil	-	0·2 K.m dist. from P/H

Notes & Comments :-
Sample no- 26. clorination needed.

H/C = house connection
S/H = street hydrant
H/Tw = hand tubewell

P/H = pumphouse

Sample Analyser
Zonal Lab. Rajshahi.

Junior Chemist
Zonal Lab. Rajshahi.

Senior Chemist
Zonal Lab. Rajshahi.

Appendix 9 - Letter operation IRP Habiganj

NETHERLANDS-BANGLADESH DEVELOPMENT CO-OPERATION PROGRAMME

DPHE-WATER SUPPLY & SANITATION PROJECTS

DPHE-OFFICE
190, ARAMBAGH, INNER CIRCULAR ROAD
DHAKA-1000 BANGLADESH
TELEPHONES : 417875, 416368

To : Project Director
Mr. S.A.K.M Shafique
Dutch Assisted Water Supply, Sanitation and Drainage Projects.
Dhaka.

From : Acting Programme Coordinator
C.M de Boer
Dutch Assisted Water Supply, Sanitation and Drainage Projects.
Dhaka.

Date : 28 May 1992
Your ref. : Nil
Our ref. : DHA/CB/FA/5930
File : C.2 + U.206
Subject : IRP Habiganj

Dear Sir,

In the period May 15th -21st a team of our office carried out testing and commissioning of the IRP in Habiganj.
From a technical point of view, construction and performance, the results were very positive. The input, cooperation and presence of the SDE, SI and the operators however was very disappointing, although they were invited several times to attend. Due to this, an excellent opportunity for training has been lost.
In order to continue supply of water the contractor has been instructed to run the installation up to June 21st.
In this context I kindly, but urgently request you to instruct the relevant officers and staff members to operate the installations in this period in consultation and cooperation with the contractor's staff.
By June 21st or preferably even before that, the installation should be run completely by PWSS staff.
As soon as we have finalized the Operation and Maintenance Manual additional training and instruction will be provided by a team from our office.

Yours Sincerely,

Acting Programme Coordinator
C.M de Boer
Dutch Assisted Water Supply,
Drainage and Sanitation Project

cc. A.Satter, Senior Water Supply Engr.

Appendix 10 - Income and expenses Drinking Water Supply Habiganj

Income per month

- 600 ½ inch-house connections, feeTK 50.--	TK 30,000.00
- 50 ¾ inch-house connections, feeTK 100.--	TK 5,000.00
	TK 35,000.00

Expenses per month

- Electricity		TK 12,000.00
- Salaries:		
Super intendent	TK 2,000.00	
Operator	TK 1,500.00	
Assistant operators	TK 1,200.00	
Plumber	TK 1,200.00	
Guard	TK 800.00	
Bill Clerc	TK 1,500.00	TK 10,000.00
Stationary		TK 500.00
Total		TK 32,500.00

So 2,500.00 Taka can be used for maintenance

Cost of house connections for a family in Habiganj

Connection fee	TK 300.00
Security deposit	TK 300.00
Clamp	TK 200.00
Application form	TK 10.00
	TK 810.00
	=====