Performance Evaluation Along with Water Audit of Devdharam Water Treatment Plant, Indore a Case Study

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Abstract

The trend of urbanization in India is exerting stress on civic authorities to provide basic requirement such as safe drinkingwater, sanitation and infrastructure. The rapid growth of population has exerted the portable water demand, which requiresexploration of raw water sources, developing treatment and distribution systems. There is a need to study the watertreatment plants for their operational status and to explore the best feasible mechanism to ensure proper drinking waterproduction with least possible rejects and its management. A case study has been conducted to evaluate the process oftreatment and to find out the problems of drinking water treatment process along with water audit in the unit situated at Devdharam water treatment plant, Indore MP, India. In general, conventional treatment is provided having a sequence of alum addition, coagulation, flocculation, sedimentation, filtration and disinfection by chlorination. Water treatment plants are playing an important role in purifyingand supplying the pure water to the people with minimum water lost. A water audit determines the amount of water lost from a water supply system and the cost of this loss to the utility. It will quantify Unaccounted for Water (UFW) and Non-Revenue Water (NRW). Comprehensive audits can give the utility a detailed profile of the water supply system and water users, allowing easier management of resources and improved reliability. It is an important step towards water conservation and, if linked with a leak detection plan, can save the utility a significant amount of money and time. The study focussed on processing and management of water treatment plant. The operation and maintenance needs to beupdated for the current requirements of people and to match up with some other plants at national and international level.

Keywords: Water treatment plant, urbanization.Non-Revenue Water (NRW), Unaccounted for Water (UFW)

1. Introduction:

Water is a precious natural national resource with an almost fixed quantum of availability. With continuous growth in the country's population, per capita availability of potable water level is going down, whereas with ever-rising standard of living of people, all around rapid Industrialization, urbanization, and demand for potable water is going up continuously. Unabated discharge of industrial effluents into water bodies is further aggravating the situation of scarcity of water of acceptable quality.There is a need for water conservation, not only to restore the fast deteriorating eco-system of the country but also to meet the inevitable emergencies of shortage even for drinking and domestic water in the near future.

1.1Performance Evaluation of Water Supply System

Water supply is basically a municipal function, to be executed by the ULB (Urban Local Body), or municipal bodies. However, since water supply schemes are capital intensive, these are financed from the state budget, borrowings from financial institutions or the external funding agencies. The Government of India provides assistance through a few centrally sponsored schemes. The performance evaluation of a treatment plant is a process to measure the functioning efficiency based on some established performance indicators such as the degree of removal of pollutants such as turbidity, colour, suspended impurities etc.

1.2Water Audit

For effective performance evaluation with respect to water losses, water audit is an essential component. A water audit is an effective management tool for minimizing losses, optimizing various uses and thus enabling considerable conservation of water not only in irrigation sector but in other sectors of water use such as domestic, power and industrial as well. The audit identifies and quantifies the areas of water use in a systematic and methodical manner so that a real understanding is gained of the actual amounts of, and the wide variety of ways in which water is consumed at a particular facility

2. Study area

Indore City is the most populated city of Madhya Pradesh with a mayor-council form of government. Indore Municipal Corporation (IMC) was established in 1956 under the Madhya Pradesh Nagar Palika Nigam Adhiniyam. Indore City is located in the centre of Indore District (fig.5.1 showing the map of Indore), on fertile Malwa Plateau at 22°43'N latitude and 76°42' E longitude. The average altitude of the project area is 550m above MSL. The project area is administered by Indore Municipal Corporation for provision of civic facilities and is spread over a geographic area of 276 km^2. IMC area is now divided into 19 administrative zones & 85 wards. As per Census records, the population of Indore city in 2011 is 19, 64,086.

The Gambhir River is a river of Madhya Pradesh. It originates from janapav near Mhow.It Flows from south to north up to until joins the Kshipra River in Ujjain city. Yashwant Sagar Dam is constructed on the Gambhir River and is the raw water source for Devdharam WTP, which is about 8 km from the source.

3. Data used

The raw water pumped from the Yashwant Sagar reservoir by both old and new raw water pump houses is supplied to the WTP at Devdharam. The design capacity of the treatment plant is 45 MLD. The raw water storage capacity of the plant is 85.5 ML. It has 8 filter beds with 4.5 ML capacity each. The capacity of the pure water tank is 270 ML. After treatment, pure water is supplied to Indore city through two CI gravity pipelines of 685 mm and 700 mm each to Bada Ganapati area.

3.1 Main Components of Devdharam Treatment plant:

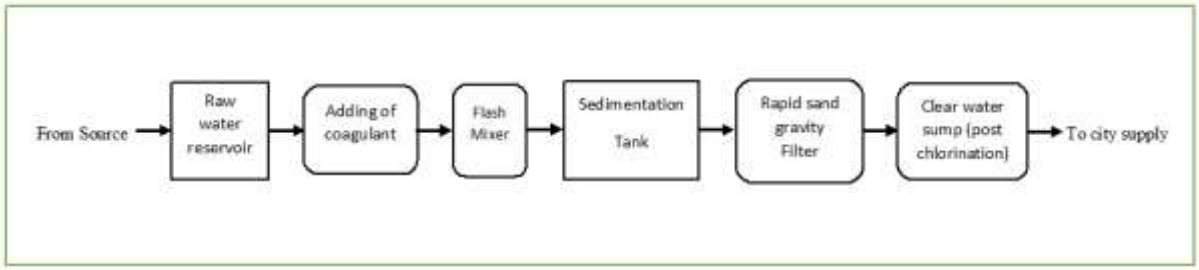

Fig.3.1 Flow Diagram of Devdharam water Treatment Plant, Indore

3.1.2 Raw Water Reservoir

The reservoir stores untreated water collected from the dam (Gambhir river).The dam is situated 8 km far from the raw water reservoir. Water comes into the raw water reservoir from the dam with the help of pumping. Devdharam treatment plant has four reservoirs having total capacity of 85.5 ML water, which are situated on the hill. The outlet level of reservoir designed such that the water comes into the WTP from the reservoir by gravity.

3.1.3 Coagulation

The coagulant neutralizes the negative protective charge on the colloidal particles and allows them to coagulate. In Devdharam treatment plant raw water comes into the open channel by, underground pipelines.

PAC (Poly Aluminium Chloride) and Alum (Al_2 $(SO_4)_3 18$ H_2O)added as coagulant at this channel, Partial flume is provided to increase the velocity of flow and hydraulic jump is also provided to create turbulence so that proper mixing of coagulant is done.

3.1.4 Flash Mixing

The coagulant is agitated quickly and thoroughly in a process called flash mixing.In Devdharam treatment plant there are two flash mixing devices installed, the duration of the flash mix chamber is carefully controlled, and typically lasts from 10-90 seconds.

3.1.5 Sedimentation

Sedimentation of flocs takes place in two parts in Devdharam WTP Up-flow sedimentation and horizontal flow sedimentation tank. 8 No. of Up-flow sedimentation tank and 8 No. of horizontal flow sedimentation tank 4.5 ML capacity each. Each Up-flow sedimentation tanks are connected with each Horizontal flow sedimentation tank by an open channel. Up-flow sedimentation tanks are compact units that required less land area. Influent enters at the bottom of the tank where flocculation takes place. Up-flow velocity decreases with an increase cross-section area of tank.The aim of the Horizontal flow sedimentation tank is to achieve equal velocity at all the points. Desludging is done in every 2 or 3 hours.

3.1.6 Rapid Sand Filter Gravity Type

The rapid sand filter or rapid gravity filter is a type of filter used in water purification commonly in municipal drinking water facilities. The gravity type of rapid sand filter use filter medium which is coarser. Devdharam treatment plant has 10 filter beds in which 8 filter beds are in working with 4.54 ML capacity each.

3.1.7 Process of Backwashing

In order to backwash a filter, the influent valve is closed and a waste line is opened. Air valve is open so that air blows back through the collector system. This will break up the surface scum and loosen the dirt. The sand used for the filter should be free from dirt, organic matter and other suspended matter, it has effective size of 0.35 to 0.6 mm The uniformity coefficient is between 1.2 to 1.7 A backwash pump forces treated water from the system back up through the filter bed. The dirty backwash water is collected by the wash troughs and can be recycled to the beginning of the plant or can be allowed to settle in a tank, pond, or basin.

3.1.8 Clearwater Sump

A Clearwater reservoir is a water-retaining structure that is used to store clean water from the treatment plant. The capacity of clear water sump at Devdharam WTP is 270 ML The water from clear water sump is feeded to 5 overhead tank by gravity they are Sangam Nagar, KilaMaidan, BSF, Pallahar Nagar, Sadar Bazar & Subhash Chouk.Which further supply to the city.

3.1.9 Post-chlorination

It is the application of chlorine to water after its treatment. The dose of chlorine should be so adjusted that the residual chlorine is about 0.1 to 0.2 ppm before the water enters the distribution system. It is used for protection against contamination from cross-connections.

3.2 Flow measurement

In Devdharam water treatment plant flow measurement is done by pump and rectangular notches. Water comes from the dam into the reservoir by 4 pumps. There are 7 pumps is installed at the dam in which 3 or 4 pumps are run simultaneously. There are 2 % transition losses are considered as the source is 8 km. away from the dam.2% of raw water given to forest dept. (gardening for pitraparvat) of total water.

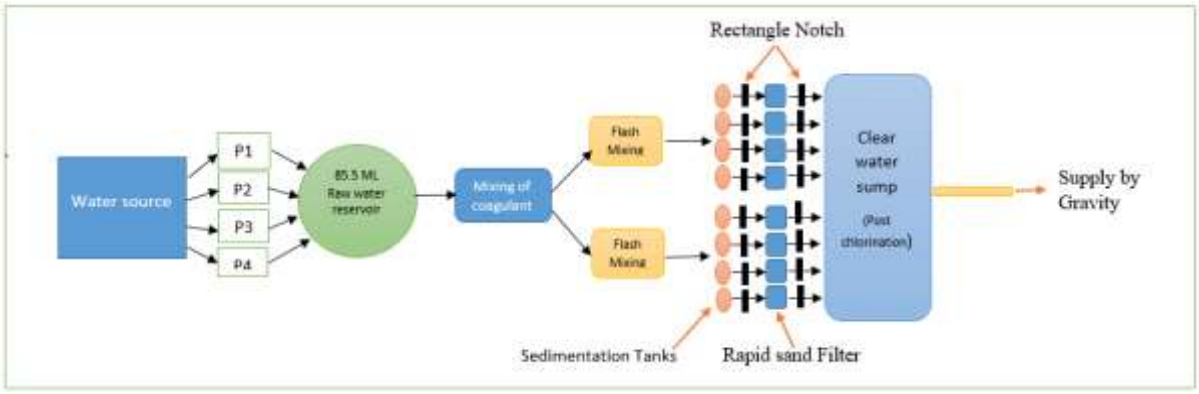

Fig 3.2 Discharge measurement for various flow of Devdharam water Treatment Plant, Indore

Discharge Measurement by Pump Flow:

Volume of water pump per day (MLD) = Flow rate of pump X time

Flow rate = 174 lps

No. of pump = 4

$Q = (174 \times 3600 \times 13X4)/10^{6}$

Q = 32 MLD appx.

Discharge Measurement by Rectangular-Notch:

$Q=2/3\ C_e \sqrt{2g}\ b_e\ h^{2.5}$

h = 0.158 m (15.8 cm)

C_e =0.686

b_e= 0.65

$q= 2/3 \times 0.686 \times 0.65 \times (\sqrt{2} \times 9.8)\ (0.022)^{3/2}$

$q=0.0376\ m^3/s$

q=Q X n (n=no of notches)

$Q= 0.0376\ m^3/s \times 8 = 3.625\ m^3/s = (3.625 \times 1000 \times 3600 \times 24)/ 10^{6} = 26MLD$

Measurement from RSF

$Q=2/3\ C_e \sqrt{2g}\ b_e\ h^{2.5}$

h = 0.158 m (15.88 cm)

C_e =0.686

b_e= 0.65m

$q= 2/3 \times 0.686 \times 0.65 \times (\sqrt{2}x9.8) (0.158)^{3/2}$

$q=0.0376\ m^3/s$

q=Q X n (n=no of notches)

$Q= 0.0376\ m^3/s \times 8 = 3.625\ m^3/s = (3.625 \times 1000 \times 3600 \times 24)/ 10^6 = 26MLD$

4. Methodology

4.1 Sampling Program

Sample of river water was taken in two frequencies at January-2019 and at
March-2019. Samples were taken in high polymerplastic containers sealed by screwcap and properly labelled. The samples were taken to the laboratory with the necessary precautions.

4.2 Analysis of Samples

Measurements of temperature, pH, Hardness, Chlorides, Fluorides, Sulphate, Nitrate are carried out for testing of water quality. The analysis of the raw water, effluent of settling unit and treated water samples from the above-said parameters is carried out as per the procedure described in Indian standard 3025, observation are also compared with Indian standard 10500:2012, Table 4.1 shows standard parameter as per Indian standard

Table 4.1: Drinking water Specification IS 10500:2012

S. No.	Characteristics	Acceptable limit	Permissible Limit In absence of alternate source	Method of test Ref. to part of IS 3025
1	pH	6.5-8.5	No relaxation agreeable	IS 3025, Part 11,7 & 8
2	TDS mg/l	500	2000	IS 3025, Part 16
3	Colour Hazen units	5	15	IS 3025, Part 4
4	Odour	Agreeable	Agreeable	IS 3025, Part 5
5	Total Alkalinity as calcium carbonate mg/l	200	600	IS 3025, Part 23
6	Total Hardness as caco3 mg/l	200	600	IS 3025, Part 21
7	Chlorides Cl mg/l	250	1000	IS 3025, Part 32
8	sulphate as SO_4 mg/l	200	400	IS 3025, Part 24
9	Nitrate as NO_3 mg/l	45	No relaxation	IS 3025, Part 34
10	Calcium Ca mg/l	75	200	IS 3025, Part 40
11	Magnesium mg/l	30	100	IS 3025, Part 46
12	Fluoride F mg/l	1.0	1.5	IS 3025, Part 60
13	E coli or Total coliform bacteria	Shall not be detectable in 100 ml sample		IS 3025, Clause 4.1.1

4.3 Water Audit

Water consumption data was gathered from the Treatment Plant. Once the amount of water used was quantified, then calculations are carried out. The particular areas of water use were identified during the site visit and walk-through phase. A water balance was then calculated based on the information collected during

the audit to determine how much water was being used for each particular purpose, on a daily basis. A Table was then prepared, which shows how much water is taken and how much water is supplied to the city. Losses in sedimentation tank and in Rapid sand filter were then calculated. Based on these data, recommendations are made for water conservation.

5. RESULTS AND DISCUSSION

1. The average total water intake in WTP is 31.80 MLD and the Average outlet of total water from WTP is 27.08MLD.
2. The weighted average water losses in the settling tank are 8.42% of total water intake. The loss of water is about 2.68 MLD.
3. The average losses of water in filters is 6.47%. (2.05 MLD).
4. The total water losses are about 4.73 MLD which is about 14.87% of the average total water intake.
5. The quality test performance for raw water resulted that hardness is 150 mg/l, turbidity is 3.85 NTU, Conductivity is 476 µs/cm TDS is 238 mg/l, Chloride is 47.5 mg/l, and Fluoride is 1.1 mg/l Sulphate 11 mg/l and Nitrate is 5.10 mg/l.
6. Water quality parameters of treated water test resulted that total hardness is 146 mg/l, turbidity is 3.29 NTU, Conductivity 452 µs/cm TDS 225 mg/l, Chloride 60.5 mg/l, and Fluoride is 1.1 mg/l Sulphate 13 mg/l and Nitrate is 5.07 mg/l. total coliform in water was (in MPN) 0 MPN/100ml.

Table 5.1: Water quality of different parameters of Treated water:-

S.No	Parameters	Treated Water Quality at Devdharam WTP	Acceptable Limit as per IS 10500-2012	Permissible Limit in the absence of alternate source as per IS 10500-2012
1	pH	6.88	6.85-8.85	No relaxation Agreeable
2	Turbidity(NTU)	3.29	1	5
3.	Colour	5	5	15
4	Odor	Agreeable	Agreeable	Agreeable
5	TDS mg/l	225	500	2000
6	Total Hardness mg/l (as $CaCo_3$)	146	200	600
7	Calcium mg/l	80	75	200
5	Magnesium mg/l as	66	30	100
8	Chloride mg/l	60.5	250	1000
9	Fluoride mg//l	1.1	1.0	1.5
10	Sulphate mg//l	13	200	400
11	Nitrate mg//l	5.07	45	No relaxation
12	E Coli or Total coliform bacteria in 100 ml sample	0	0	0

Table 5.2 Total Losses in February-2019

S.No.	Losses of Water		The population that can benefit
	Percentage	ML	
1	17 %	148.0785(monthly) 5.2885 (daily)	39,174 daily

Table 5.3 Total Losses in March-2019

S.No.	Losses of Water		The population that can benefit
	Percentage	ML	
1	15 %	130.7332(monthly) 4.2172 (daily)	31,238 daily

6. Conclusions

Based on the results derived and interpretation following major conclusions can be made:

1. As per the study water losses in the units of Devdharam water treatment plant is higher than the acceptable, it evaluates that units are not performing as per requirement.
2. Flow measurement devices are required to be necessarily installed for continuous monitoring of water losses.
3. If prevented the current losses of water it can serve 35004 persons of the city at the rate of 135 lpcd.
4. From water quality parameters of the outlet of sedimentation process, it can be evaluated that removal of solids is not significant and chloride is endued due to use of PAC as a coagulant.
5. An increase in turbidity after filtration indicated filtration unit is not performing as required.
6. Characteristics of treated water indicate that the need for improved backwashing arrangements for filter beds is required.
7. Visual inspection of Treatment units indicates that units do not sound well structurally and needed to be repaired.

6.1 Rehabilitation Plan

Rehabilitation Plan must be carried out they are-

1. **Short term measures**

Replacement/repair of valves, specials, pipes joints, plastering pointing, water taps, water connections at WTP, improvement in backwash systems

2. **Medium-term measures**

Installation of flow meters at inlets and outlets, grouting, epoxy mud mortar plastering.

3. **Long term measures**

Treatment of backwash water with sludge dragging bed, replacement of mechanical and electrical equipment as per requirement.

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