Augmentation of Underground Pumped Out Water for Potable Purpose from Coal Mines of Jharia Coalfield

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ABSTRACT

Millions of gallons of mine water is being discharged daily from underground coal mines. This valuable water resource of acceptable quality, becomes contaminated with various domestic and industrial trade effluents and subsequently is just wasted while putting on an enormous energy cost burden on the underground mines.

Further costs are incurred on abstraction of water from adjoining surface water bodies containing this water and also additional costs are required for treatment to meet the water quality objective criteria. The National Water Policy, 1987, emphasises the need to augment the water availability to meet various demands from such sources.

The present study is aimed to provide an insight on water quality utilisation propensity from underground coal mines of the Jharia Coalfield. The need to provide potable water supply in the densely and thickly populated, highly industrialised Jharia Coalfield cannot be over-emphasised. Mining populations in the region have been facing acute shortage of water supply and in some places people have to walk a few kilometers to collect the water for their daily needs. Epidemics also occur due to water-borne diseases, due to the non-availability of a properly treated water supply. This study highlights that this underground mine water can be augmented to meet various water supplies, particularly for drinking purposes. Treatment of this water resource at some places is also presented. A simple scheme for augmentation of underground mine water for potable purpose is also suggested.

INTRODUCTION

In the age of a water crisis the study of the use of underground pumped out mine water of the Jharia Coalfield for potable purpose has taken an importance. The water available from the various sources may, or may not, contain impurities. During underground mining lots of water which is present inside the earth's crust is released by mining and forms mine water, which when pumped out becomes contaminated with different industrial effluents and looses its acceptable value. The Jharia Coalfield is the part of the Gondwana basin having its own unique geological strata. In this geological condition the water availability is very uneven, thus the people residing in these areas have to face a lot of water problems. There is no adequate and proper water supply in the region.

Millions of gallons of mine water is being pumped out daily from underground coal mines in the Jharia Coalfield. This valuable water resource which otherwise is of acceptable quality, except for its hardness content, is getting contaminated with various domestic and industrial trade effluents and subsequently is just wasted while incurring enormous costs in energy for pumping requirements for the underground mines [1,2]. Further costs are incurred on abstraction of water from adjoining surface water bodies containing this mine water and also additional costs required for treatment to meet the water quality objective criteria. The National Water Policy, 1987, emphasises the need to augment the water availability from such sources as well to meet various water demands of the local people [3]. Sometimes in the summer season drought-like conditions prevail, compelling the mining community to use contaminated water which affects the public health. It has been revealed from health studies that people residing in mining areas suffer from various water-borne diseases like cholera, typhoid, dysentery, jaundice in addition to skin diseases and hook worms.

WATER DEMAND IN JHARIA COALFIELD

For a water supply project it is necessary to determine the total water demand by the city which includes domestic water demand, commercial water demand, fire demand, demand for public use and compensate losses demand as given below in Table 1 [4]:

Table 1. Net Water Demand

Domestic use	135 LPCD
Industrial use	40 "
Public use	25 "
Fire demand	15 "
Losses, wastage and thefts	55 "
Total	270 LPCD

Source : Birdie G.S. and Birdie J.S. Water Supply and Sanitary Engineering, Dhanpat Rai and Sons., New Delhi, 1990.

There has been an acute shortage of water in many places within the Jharia Coalfield. The quantity of water available for an individual for day to day use for various purposes along with the corresponding WHO recommended quantity is presented in Table 2.

The population of Dhanbad town and the Jharia Coalfield, which is at present at the level of 12.0 lakhs, is likely to go up to 15 lakh by 2001 [5]. The potable water demand for an estimated population of 15.0 lakh by 2001 AD at 30 GPCD (135 LPCD) works out to 45 Mgd. Considering 10% for loss in distribution and 25% water demand for private industries, the total demand comes to 49.5 Mgd. The userwise break up of demand is as follows:

(a)	BCCL employees	-	19.5 Mgd
(b)	Rehabilitation colonies (non BCCL)	-	23.0 Mgd
(c)	Dhanbad and Baghmara towns	-	7.0 Mgd

Table 2. Quantity of Water Available for an Individual for Day to Day Use

Sl No.	Purpose	WHO's recommendation litre/person/day (A)	Quantity available litre/person/day (B)	Percent shortage (%) (C)
1.	Drinking/ Cooking	15	8.5	43.3
2.	Bathing/ Personal Washing	60	12.0	80.0
3.	Utensiles Washing	15	5.0	66.6
4.	Cloth Washing	20	7.5	62.5
5.	House Washing	10	5.0	50.0
6.	Flushing/Refuse disposal Washing	60	15.0	40.0
7.	Garden	10	-	100.0
8.	Wastage	20	7.0	65.0
	Total	210 Lits.	60.0 Lits.	71.42

$$C = \frac{A - B}{A} \times 100\%$$

The Mineral Area Development Authority (MADA) which is the 'sole source' of water supply to the non-BCCL population is supplying water to Dhanbad and Baghmara towns also. The industrial water demand of the Jharia Coalfield has been assessed as 34 Mgd.

On the completion of the Jharia Reconstruction Scheme the underground mines shall be pumping 61 Mgd [5]. The domestic water demand comes to 49.5 Mgd and the industrial water demand has been assessed as 34 Mgd. The total demand comes to 83.5 Mgd and the availability would be only 61 Mgd, thus the whole of the underground pumped out mine water can be treated for potable purposes as this is of good quality except hardness (Gurdeep Singh, 1990). This will not only meet potable water demand considerably but also cut down the treatment costs under existing conditions. The rest of the water demand will be met from the River Damodar and it's tributaries. Even though the underground mine water is fully taped it does not meet the total demand and cost has to be incurred for abstraction of water from surface water bodies to meet the rest of the demand. At the River Damodar and it's tributaries are rain-fed the flow becomes very negligible in the summer. The water supply becomes a great problem during the summer. Thus, in such a condition mine water is the ideal source which can be augmented to meet the various water supplies particularly for domestic purposes which is in accordance with the National Water Policy, 1987 [3]. The National Water Policy, 1987, emphasises the need to augment the water availability from such sources as well as to meet various demands of the local people.

MATERIALS AND METHODS

Samples of pumped out mine water discharges from various underground coal mines of the Jharia Coalfield were collected and analysed according to standard methods prescribed in IS:2488 [6] and the Manual on Water and Wastewater Analysis NEERI [7]. The samples were directly collected at the surface from the pipe at the exit point of mine water discharge during one shift of work. Samples were collected in cleaned polyetheylene containers which were rinsed two to three times initially with a portion of the sample.

Some of the parameters such as pH, temperature, conductivity and total dissolved solids have been evaluated on the spot during sample collection itself. The other water quality parameters were analysed at a laboratory after preserving the samples and storing them in a refrigerator.

UNDERGROUND MINE WATER QUALITY

A classification of underground mine waters, as arrived at on the basis of analysis of mine waters from various coal mines of the Jharia Coalfield, is given in Table 3. General water quality characteristics under each category are summed up in Table 3. Most of the mine waters fall under category A2 which have high to medium concentrations of dissolved solids, hardness, sulphate with low to medium concentration of suspended solids. Biochemical parameters (BOD, COD) and toxic metals are present at insignificant levels. Waters of category A1, which are slightly alkaline in nature, differ from those of category A2 in that they are not hard and contain comparatively low concentration of dissolved solids and sulphate. Chloride concentrations of both the categories are not very different and are generally at an acceptable value. Mine waters of category A3 contain very high concentration of dissolved solids particularly sulphate and chloride with very high hardness content and their occurrence is rare and limited to some of the worst affected mine fire areas [8]. All the mine waters revealed bacteriological contamination and special attention needs to be paid to disinfection.

CLASSIFICATION OF MINE WATERS BASED ON HARDNESS

Water samples collected from the underground mines were hard to very hard which is revealed from Table 3. About 75% of the samples were found to be lying in the very hard category. This is the main cause of the underground mine waters non-acceptance among the public, particularly due to difficulty in cooking and consumption of lots of soap for washing and bathing purposes. The release of phosphates from the soaps and detergents consumption is also contributing towards the eutrophication of confined water bodies. Further hardness content in the mine waters also results in scale formation.

Table 3. Classification of Mine Waters

	Category of the Minewaters		
	A-1	A-2	A-3
Water Quality Factors			
a. pH	7.5-8.5	7.0-8.5	6.0-8.0
b. Alkalinity (mg/l $CaCO_3$)	200-7000	100-500	10-30
c. Hardness(mg/l $CaCO_3$)	50-150	200-1500	1000-2000
d. T.Dissolved Solids(mg/l)	300-700	500-1500	1500-2500
e. T.Suspended Solids(mg/l)	5-30	12-50	10-50
Bio-Chemical Parameters			
a. DO (mg/l)	5.5-8.0	5.0-8.0	5.0-8.0
b. BOD (mg/l)	<1	<1-2	<1-2
c. COD (mg/l)	8-30	15-50	15-60
Element or Ion Content			
a. Calcium(mg/l)	10-50	50-200	100-150
b. Magneisum (mg/l)	10-30	40-180	80-100
c. Total Iron(mg/l)	0-2	0-5	0-5
d. Sulphate(mg/l)	10-100	100-800	1000 and above
e. Chloride(mg/l)	18-40	22-45	80-400
f. Bacteriological Contamination Coliform Organisms (MPN/100 ml)	0-180	6-180	0-18

PUMPED OUT MINE WATER TREATMENT

Mine water in general is treated mainly by conventional methods using aeration followed by flocculation with rapid and slow mixing and sedimentation. The water enters the rapid gravity filters after which it is disinfected by chlorination and supplied to the consumers. In the case of mine water with significant hardness (> 300 mg/l) softening by lime soda process or ion exchange process is additionally practiced. Addition of coagulant in excess to the mine water will hasten flocculation and increase bactericidal efficiency thus it is economical to use the minimum quantity of coagulant and to depend on chlorine for bacterial safety of the water.

In the Jharia Coalfield there are a number of collieries, the workings of which facilitate the pumping of millions of gallons of water which is being discharged, putting on enormous costs on energy for pumping. Some of the collieries have their own treatment plants in the vicinity of the mine for the treatment of mine water and supplying it to the mining community. The schematic layout of such treatment plants is given in Figure 1. Many of these units have not been observed in proper operating conditions like those of Godhar, West Modidih, Jealgora, Bansjora, East Basuria, Lodna and Alkusa. In many of the cases the filter beds were found to be choked and the quality of water obtained after treatment was not of the required standard. In some cases the treated water had either excess or deficient of residual chlorine which is objectionable for the aesthetic and public health point of view.

PROPOSED WATER SUPPLY SCHEME FOR MINING AREAS

A scheme is being proposed for the treatment of the mine water supply which broadly consists of:

(a) the collection system involving pumping of raw water and its transmission through pipe to the collection sump of the treatment plant;

(b) the treatment system including various stages of treatment so as to produce water of potable quality in terms of Standard Indian Practice;

(c) the clear water transmission and storage system which would involve pumping of the treated water from the clean water sump to the zonal reservoirs and from the zonal reservoirs to the consumer point with the help of primary main and secondary pipes.

The schematic diagram of the proposed water treatment scheme for the collieries is shown in Figure 2. It is clear from the figure how water is being transported from the colliery up to the treatment plant, from pit head sump of raw water pump to raw water storage reservoir. The need for a storage reservoir is very essential because of the pumps and electricity as well as providing a sedimentation facility.

The various steps involved in treatment are aeration which is being provided for the removal of iron and other dissolved gases like H_2S, CO_2, etc. Alum mixing chamber has been proposed for the treatment so that the clogging of the filters is not frequent. Alum mixing has been provided so that during the period of water being highly turbid the turbidity can be easily removed. The clariflocculator helps in flocculation and getting clarified water from the above unit. The water is then passed to the pressure filters. The pressure filters are being proposed

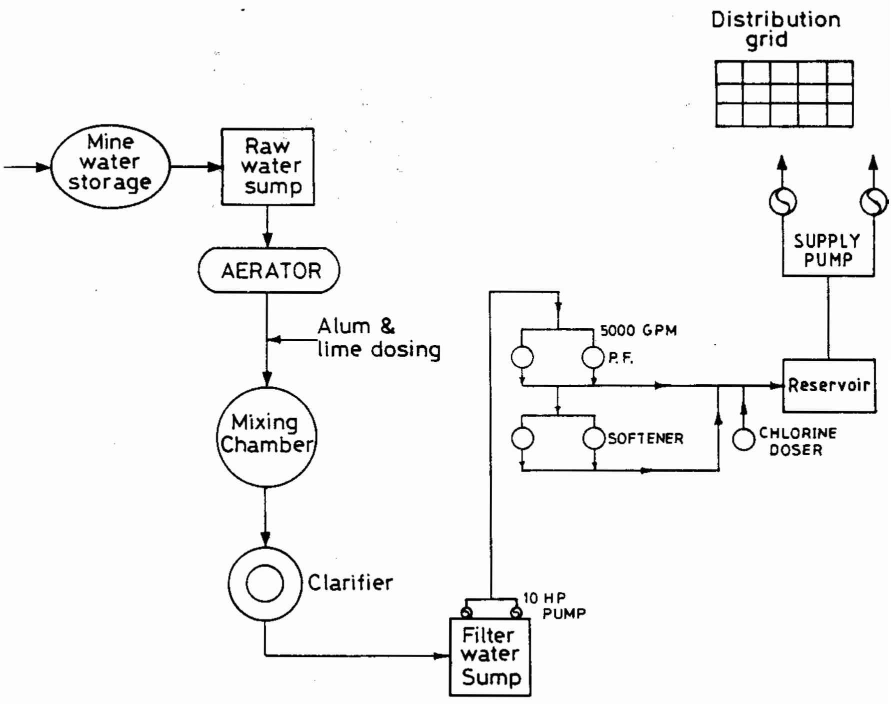

Figure 1.

Schematic layout of water treatment plant in practice at some of the mine sites

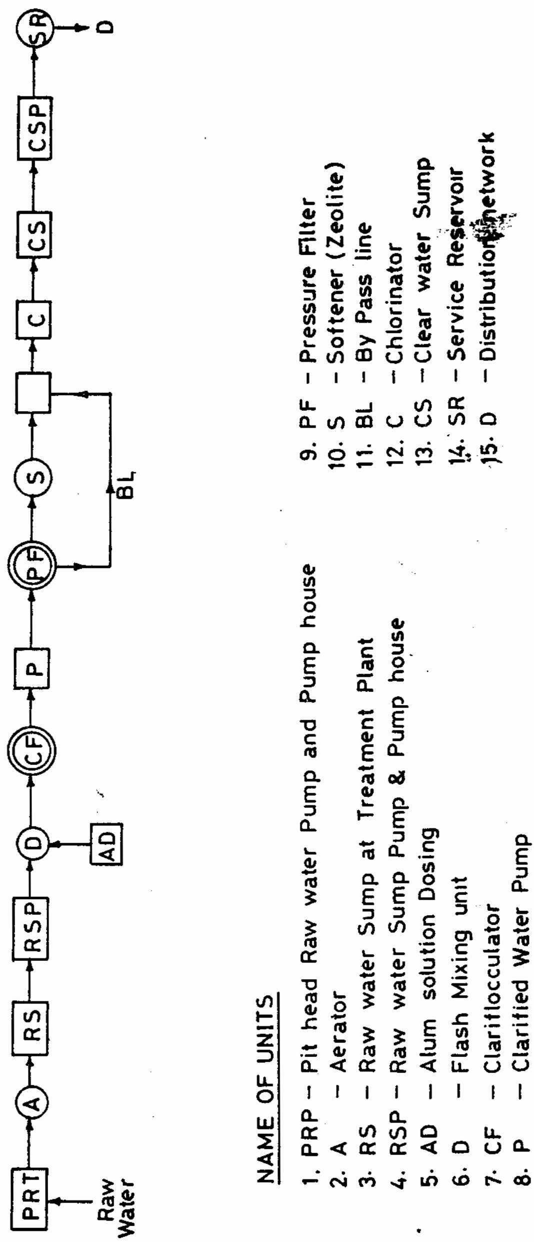

Figure 2. Flow diagram for proposed water supply system

seeing the small capacity of treatment plant. In general practice this type of filter is being proposed for individual colony or industry only. Filters are being used for the removal of bacteria, colour, taste, odours and producing clear and sparkling water.

The mine water, as we know, is hard enough, thus it has been proposed to use a base exchange softener for this purpose. The above type of treatment proves to be beneficial in case of water having high salinity as well as a considerable amount of chloride and sulphate content. Non-carbonate hardness is usually removed more cheaply by the ion exchange process than by a soda lime process. When the water does not contain a significant amount of hardness selective treatment can be done. The base exchange softening which is being proposed involves a number of reactions as shown below, R being used to indicate the anionic portion of the material which does not enter into the reaction. Thus Na_2R means the base exchange material containing Na whereas CaR and MgR represent the same material after the Na has been exchanged for Ca and Mg by the removal of base material from water and the release of an equivalent amount of Na to the water. The ionic reaction is as follows:

$$Ca^{++} + Na_2R \rightarrow CaR + 2Na^{+}$$

In terms of hardness producing compounds the following reactions occur.

$$Ca(HCO_3)_2 + Na_2R \rightarrow CaR + 2NaHCO_3$$

$$CaSO_4 + Na_2R \rightarrow CaR + Na_2SO_4$$

$$Mg(HCO_3)_2 + Na_2R \rightarrow MgR + 2NaHCO_3$$

$$MgSO_4 + Na_2R \rightarrow MgR + Na_2SO_4$$

As the Na has been removed from the material by base exchange, regeneration is practiced to restore the Na by backflushing with sodium chloride. The water coming out of the softener is extremely soft (even zero hardness can be attained) and is being proposed to be mixed with filtered water by a bypass line as extremely soft water is not required for public water supply. The chlorination is being proposed to be done by chlorine gas as it proves to be more efficient and fast. It is also being proposed to have a check on a regular basis for the treated water quality with free residual chlorine concentration maintained between 0.2 to 0.4 mg/l. This will help to check the spread of epidemics in the coal mining areas of Jharia Coalfield.

In the above proposed treatment plant the cost incurred in construction and running is high and generally it may not be possible for the mining authorities to provide such treatment as proposed at the mine site in the present situation. Thus, a low cost treatment scheme has been proposed showing the schematic diagram in Figure 3.

It has been proposed to pump the mine water from the underground mine to the reservoir so that aeration is achieved. The water is then pumped from the reservoir to the lime soda chamber. By adding lime and soda non soluble carbonates can be formed and these can be settled in the sedimentation tank as shown in the figure. Coagulant can be used if it is necessary to bring down the fine particles in the same chamber. In the sedimentation chamber, calcium

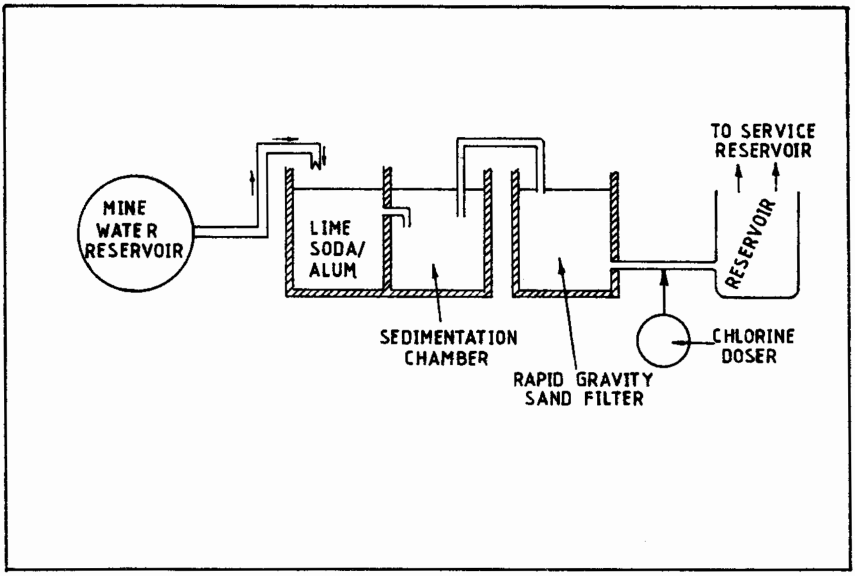

Figure 3.

Proposed low cost treatment scheme

carbonate, magnesium hydroxide and magnesium carbonate settles down. The water is then proposed to enter a rapid sand gravity filter which removes suspended matter, colour, odour and bacteria from water. The water as soon as it comes out is chlorinated and stored in a reservoir. Chlorine gas is being proposed for chlorination and final disinfection. The free residual chlorine should be within 0.2 to 0.4 mg/l. The third way to reduce hardness is to blend the pumped out mine water with softer surface waters/river water and the treatment costs can be considerably reduced.

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