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Analyses of abandoned coal mine pit water quality compared to the water of regular, conventional sources in respect of its utilitarian perspectives: a special reference to selected abandoned open cast mine pits of Satgram area, Raniganj coalfield, West Bengal

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ABSTRACT

The present study was conducted to investigate the status of water quality and to determine the Water Quality Index (WQI) of three abandoned open cast coal mine pits named Harabanga O.C.P., Damalia O.C.P. and Ratibati O.C.P. of Satgram area, Raniganj coalfield, West Bengal, India for three consecutive seasonal phases. These are pre-monsoon, monsoon and post-monsoon from 2019 to 2020. This paper deals with the study of the most commonly used water quality parameters as per IS 10500: 1991 Drinking Water-Specification and developed Water Quality Index (WQI) from the mean value of the season-wise Analysis of the said selected O.C.P.s water samples. The WQI of Harabanga O.C.P., Damalia O.C.P. and Ratibati O.C.P. are 90.3243, 82.8558 and 92.9864 respectively. The results indicate that all the O.C.P.s show very poor water quality. Compared to the water of regular, conventional sources in Raniganj coalfield with respect to its utilitarian perspectives. Simultaneously during the investigatory phase voting technique was also applied to determine or understand the ground reality related to the said abandoned O.C.P.s. An ideal questionnaire was prepared on the basis of associated issues and problems like pollution, water quality, fishing activity, agricultural activity and domestic activity among selected respondents, like Local people, Mining workers, Local administrators, Environmentalists, Policymakers and Researchers. From the survey it is clearly revealed that local people are utilizing the O.C.P.s water only for agricultural activity and fishing activity etc. not for drinking and domestic purposes. Therefore the implementation of suitable water treatment and sustainable management plans are needed from the competent authorities for utilitarian perspectives of the O.C.P.s.

Key words : *Open cast coal mine pits, Sustainable management plans, Water quality, Water Quality Index (WQI), Utilitarian perspectives.*

([1]Research Scholar,[2]Professor, [*3]Vice Chancellor)

Introduction

In a developing country, coal resources are vital, conventional energy sources and significant factors to the national economy and its expansion (Wellen *et al.,* 2018). In 1774, Coal mining was for the first time initiated in the Raniganj coalfield during the British East India period. It covers 1530 km^2 area and contains near about 1306 km^2 of coal bearing land (Gupta *et al.*, 2013). In coal mining activities surface or open cast mining process has increased globally during the past few decades. But the open cast process creates a drastic alter in the landscape and heavy atmospheric pollution (Dale *et al.*, 2011). The post-mining phase pits formed in the open cast mining process, stretch below the groundwater table (Palit *et al.,* 2014). The lack of knowledge on and information about open cast pits continue to obstruct their proper management and maintenance (Palit *et al.,* 2019). Open cast pits are generally very deep, encompassed by steep rock walls and usually without nearshore (Klapper and Schultze, 1995; Geller *et al.*, 1998, Lessmann *et al.*, 2000, Kalin *et al.*, 2001, Boland and Padovan 2002). On the basis of hydrologic conditions, atmospheric situation and pit morphology, there are 2 basic types of pit lakes: 1) terminal & 2) flow-through (Sánchez-España *et al.,* 2014). Water quality of mine pits generated at a previously openedmine pit presents a wide variability - heavy metal: rich to near neutral; the water qualityranges from acidic to low TDS etc. In general, the chemical nature of mine pits depends on several factors that may alter with time as it fills up (Davis *et al.,* 2003). Statistical analyses on coal mine pit water suggested that it is fit for irrigation but egregiously useless to be used as drinking water or domestic purposes, mainly due to its upraised concentration of different types of heavy metals (Prathap and Chakraborty, 2020). The water quality index is a widely accepted practice to identify the water quality information for the different needs of humans. Basically, Water Quality Index is calculated statistically from different analyses results and gives a single value. Therefore water quality index is applied to represent multiple water quality data in a simpler and permanent form (Singh *et al.*, 2013). There are various water quality indices that have been applicable all over the world among them, Brown *et al.* (1972) formulated a water quality index that is widely used. WQI investigation of various coal mine pits of Raniganj coalfield significantly stated that pit water is inferior quality and becomes more waste in monsoon season (Mondal and Palit, 2019).

The present study is aiming to identify the status of water quality and to determine the WQI of selected open cast coal mine pits of Satgram area, East-

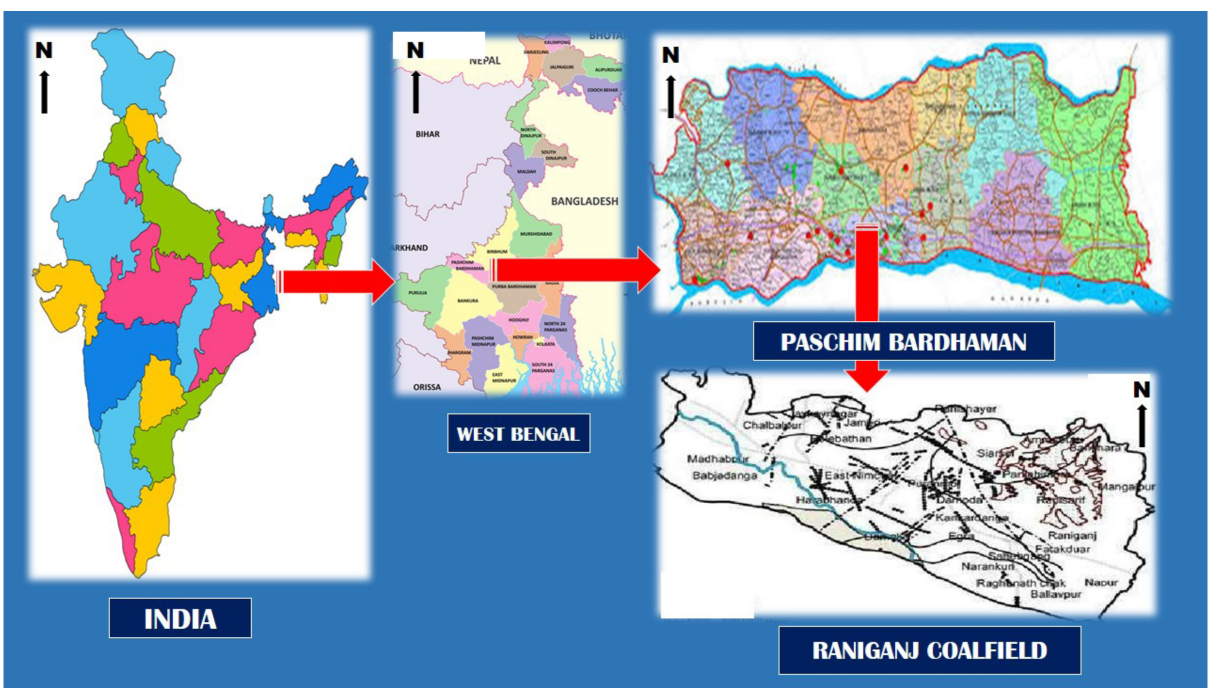

Fig. 1. Geographical location of Raniganj coalfield

ern Coalfield Ltd. under Raniganj coalfield, West Bengal, India for three successive seasons, pre-monsoon, monsoon, post-monsoon from 2019 to 2020 and to compare the same to the water of regular, conventional sources in Raniganj coalfield in respect of its utilitarian perspectives, simultaneously using voting techniques ofideal questionnaire survey to understand the ground reality.

Study Area

Raniganj coalfield is geographically bounded by Ajoy River in North and Damodar River in South, spreading over Paschim Bardhaman, Purulia, Birbhum and Bankura districts in West Bengal, India.

Satgram area is one of the 14 coal operational area of Eastern Coalfield Ltd. It is located in Asansol subdivision of Paschim Bardhaman and partially in Bankura Sadar subdivision in Bankura, West Bengal.

Harabanga abandoned O.C.P. is one of the selected study site in Satgram area, E.C. Ltd., situated in Harabanga village under Tirat gram panchayat, Raniganj Block of Paschim Bardhaman. Geographically it is located at $23^0 39'52''$ N latitude and $87^0 01'44''$ E longitude.

Damaliaabandoned O.C.P. is also a selected study site in the said area of E.C. Ltd. It is situated in South of Harabanga village under Tirat gram panchayat, Raniganj Block of Paschim Bardhaman. The geographical location of this O.C.P. is $23^0 36' 32''$ N Latitude and 87^0 04' 00'' E Longitude.

Fig. 3. Harabanga abandoned O.C.P., Raniganj coalfield

Another study site Ratibati O.C.P. is located at Asansol Municipal Corporation, behind National Highway 19 (India) in the same district. The geographical location of this O.C.P. is $23^0 36' 20''$ N Latitude and 87^0 04' 26'' E Longitude.

Materials and Methods

The present study is purely based on direct water

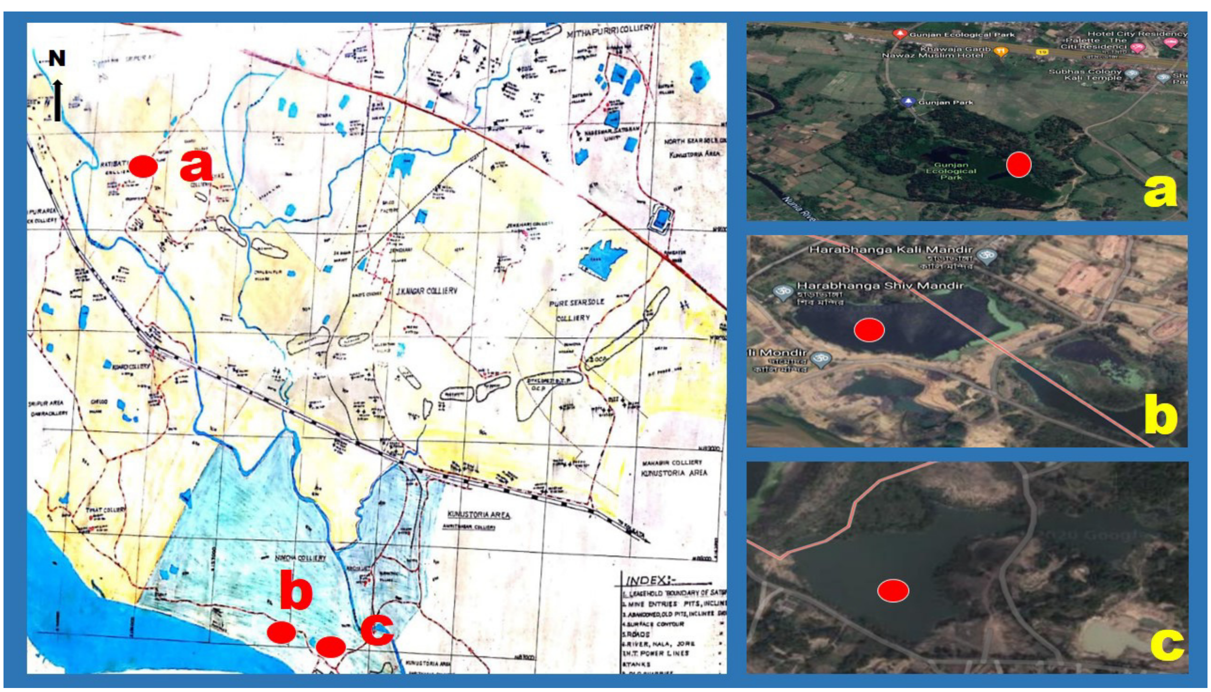

Fig. 2. Location of selected abandoned O.C.P. in Satgram area, Eastern Coalfield Ltd. site map with satellite view; a. Ratibati O.C.P., b. Harabanga O.C.P., c. Damalia O.C.P.

samples collected from the three study sites. The primary data has been collected in three different seasons from 2019-2020, i.e. pre-monsoon (from March to May, summer season), monsoon (from June to September, rainy season) and post-monsoon (from November to February, winter season). After that, it has been brought to the laboratory for analyses by using APHA 23rd Edition, 1060 on the basis of the most commonly used water quality parameters as per IS 10500: 1991 Drinking Water-Specification and has been taken to generate Water Quality Index (WQI) from the mean value of the season-wise analysed data of said water samples.

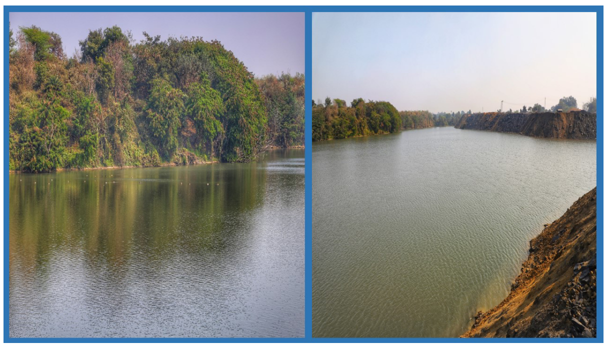

Fig. 4. Damalia abandoned O.C.P., Raniganj coalfield

Fig. 5. Ratibati abandoned O.C.P., Raniganj coalfield

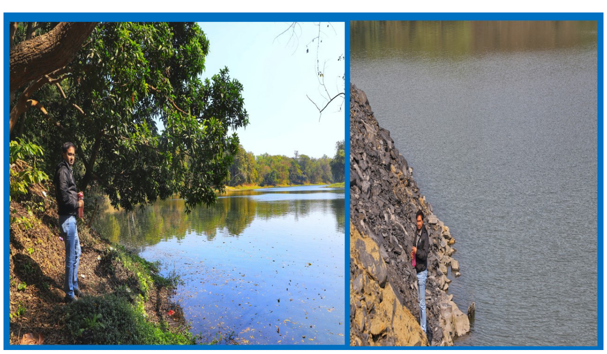

Fig. 6. Collection of water samples from abandoned O.C.P.s for analyses

Water Quality Index (WQI) was calculated Weighted Arithmetic Index method (Brown *et al.*, 1972) using MS-Excel

Step 1. Calculate the unit Weight (Wn) factor for each parameters by using the formula

$$Wn = \frac{K}{Sn}$$

$$\text{Where, } K= \frac{1}{1/S_1 + 1/S_2 + 1/S_3 + \ldots\ldots\ldots + 1/Sn} = \frac{1}{\sum \frac{1}{Sn}}$$

Sn = Standard desirable value of the n^{th} parameters

On summation of all selected parameters unit weight factors, W_n=1(unity)

Step 2. Calculate the Sub-Index (Q_n) value by using the formula

$$Qn= \frac{(Vn-V0)}{(Sn-V0)} * 100$$

Where

V_n= mean connection of the n^{th} parameters

S_n= Standard desirable value of the n^{th} parameters

V_0= Actual value of the parameters of the pure water (generally $V_0=O_2$ for most parameters except for pH

$$QpH= \frac{[(VpH-7)]}{[(8.5-7)]} * 100$$

Step 3. Combining Step 1 & Step 2, WQI is calculate as follows

$$\text{Overall WQI}= \frac{\sum WnQn}{\sum Wn}$$

Then voting technique was applied to determine or understand the ground reality related to the said abandoned O.C.P.s. An ideal questionnaire was prepared on the basis of associated issues and problems

Table 1. The water may be classified into five types based on computed WQI, developed by Brown *et al.*, 1972 (Chatterji and Raziuddin, 2002)

Water Quality Index Level	Water Quality Status
0 -25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
>100	Unfit for drinking

like pollution, water quality, fishing activity, agricultural activity and domestic activity. After that questions were put to the selected respondents, like Local people, Mining workers, Local administrators, Environmentalists, Policymakers and Researchers.

After that the said O.C.P.s' water quality was compared with different types of standard drinking water samples in Raniganj coalfield, as per IS 10500: 1991 Drinking Water-Specification. Whereas Correlation statistics were performed by using SPSS statistical software version 16.0 for analysing the data set and get a better result. ANOVA (single factor) was also applied to analyse the impact of different variances of O.C.P.s and different types of standard drinking water samples.

Results

The study was done in different climatic condition like, pre-monsoon, monsoon and post-monsoon. Different most commonly well used water quality parameters as per IS 10500: 1991 Drinking Water-

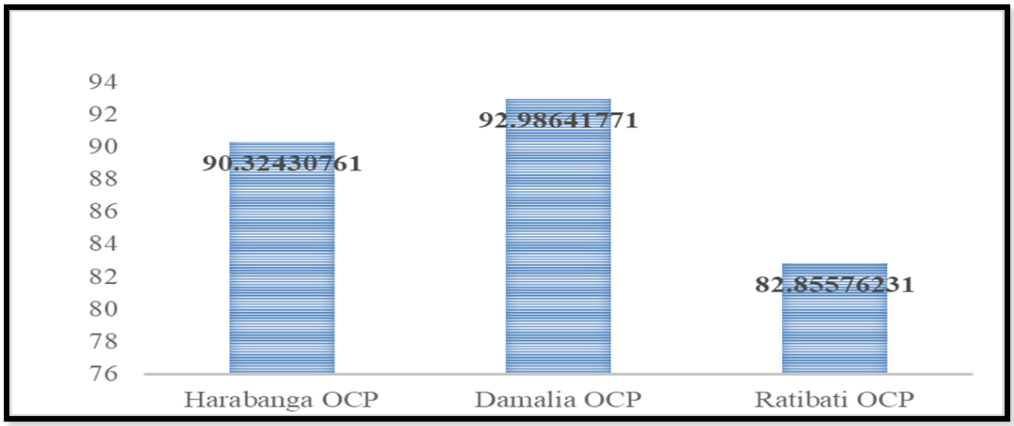

Fig. 7. Bar graph shows compression of Water quality Index (WQI) of three selected abandoned O.C.P.s.

Table 2. Water quality analyses show mean value of limnology of three selected abandoned O.C.P as IS 10500: 1991 Drinking Water-Specification

Parameters	Harabanga O.C.P. (Mean Value)	Damalia O.C.P. (Mean Value)	Ratibati O.C.P. ((Mean Value)	Maximum permissible Limit (as per ISI)
Turbidity NTU	0.01	0.015	0.001	5
Dissolved Solids mg/l	132	135	125	500
PH. Value	6.78	6.96	6.85	6.50 to 8.50
Oil and Grease mg/l	0.01	0.01	0.001	0.01
Total residual chlorine mg/l	0	0	0	0.2
Ammonical Nitrogen (as N) mg/l	3.64	2.77	3.24	0.1
Nitrite Nitrogen (as NO_2) mg/l	0	0	0	0.1
Arsenic (as As) mg/l	0	0	0	0.05
Hexavalent Chromium (as Cr) mg/l	0	0	0	0.05
Copper (as Cu) mg/l	0	0	0	0.05
Cyanide (as CN) mg/l	0	0	0	0.05
Chloride (as Cl) mg/l	15	18	9	250
Flouride (as F) mg/l	0	0	0	1.5
Sulphates (as SO_4) mg/l	0	0	0	150
Nitrates (as NO_3) mg/l	0	0	0	45
Phenolic Compounds (as C_6H_5OH) mg/l	0	0	0	0.005
Iron (as Fe)mg/l	0.42	0.3	0.36	0.3
Total Hardness (as $CaCO_3$) mg/l	30	32	25	300
Total Alkanities (as $CaCO_3$) mg/l	31	36	23	300

Specification were taken into consideration to analyse the total water quality and then considered and cited the mean values in tabular form.

Tabular cited the mean value of pre-monsoon, monsoon and post-monsoon water quality data of the said selected abandoned O.C.P.s.

WQI values of selected abandoned O.C.P.s are presented in tabular form (Table 3, Table 4, and Table 5)

Table 6. represents the water quality status and WQI values are presented in bar graph in Figure 7. of the said O.C.P.s.

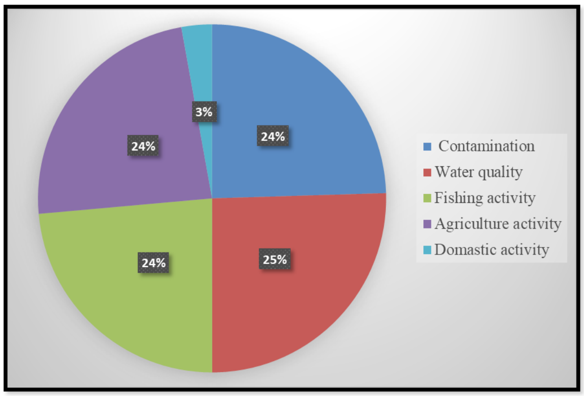

Fig. 8. Pie chart showsresponse from respondents regarding O.C.P.s issues or problems

Arranged an ideal questionnaire survey among different selected above-cited respondents. Each response equals 5 in this test and in respondent group consists of 30 people. After getting the response, a response percentage has been taken into consideration (Table 7) and plotted in the pie chart (Fig. 8).

After comparing the O.C.P.s' water quality status with the different types of drinking water standards in Raniganj coalfield (Table 8), comparative values are plotted in graph (Figure 10) and computed ANOVA to determine the views and dependency of variables between the groups (Table 9).

Discussion

WQI of the selected O.C.P.s in different seasons (pre-monsoon, monsoon, post-monsoon) of the study period are developed from important various commonly used parameters (Tables 3, 4 & 5). The WQI clearly shows that the status of Harabanga O.C.P., Damalia O.C.P. and Ratibati O.C.P. is 90.3243, 82.8558 and 92.9864 respectively are very poor as Brown *et al.*, 1972 (Table 6).

From the voting technique (Table 7 and Figure 8) analyse the ideal questionnaire on the basis of associated issues and problems of contamination, water quality and different mode of utilities of the selected

Fig. 9. Different kind of activities related with the abandoned O.C.P.s

Table 3. Determination of Water Quality Index(WQI) of Harabanga abandoned O.C.P. as IS 10500: 1991 Drinking Water-Specification

Parameters	Maximum permissible limit (as per ISI) Sn	1/Sn	Σ1/Sn	K=1/ (Σ1/Sn)	W1= K/Sn	Ideal Value V0	Mean Conc. Value (Vn)	Vn/Sn	Vn/Sn *100=Qn	WnQn	WQI
Turbidity NTU	5	0.2	409.359	0.00244284	0.00048857	0	0.01	0.002	0.2	9.77137E-05	90.3243
Dissolved Solids (mg/l)	500	0.002	409.359	0.00244284	4.8857E-06	0	132	0.264	26.4	0.000128982	
PH. Value	8.5	0.11765	409.359	0.00244284	0.00028739	7	6.78	0.7	70	0.020117525	
Oil and Grease mg/l	0.01	100	409.359	0.00244284	0.24428424	0	0.01	1	100	24.42842359	
Total residual chlorine mg/l	0.2	5	409.359	0.00244284	0.01221421	0	0	0	0	0	
Ammonical Nitrogen (as N) mg/l	0.1	10	409.359	0.00244284	0.02442842	0	2.65	26.5	2650	64.7353225	
Nitrite Nitrogen (as NO2) mg/l	0.1	10	409.359	0.00244284	0.02442842	0	0	0	0	0	
Arsenic (as As) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Hexavalent Chromium (as Cr) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Copper (as Cu) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Cyanide (as CN) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Chloride (as Cl) mg/l	250	0.004	409.359	0.00244284	9.7714E-06	0	15	0.06	6	5.86282E-05	
Flouride (as F mg/l)	1.5	0.66667	409.359	0.00244284	0.00162856	0	0	0	0	0	
Sulphates (as SO4) mg/l	150	0.00667	409.359	0.00244284	1.6286E-05	0	0	0	0	0	
Nitrates (as NO3) mg/l	45	0.02222	409.359	0.00244284	5.4285E-05	0	0	0	0	0	
Phenolic Compounds (as C_6H_5OH) mg/l	0.005	200	409.359	0.00244284	0.48856847	0	0	0	0	0	
Iron (as Fe) mg/l	0.3	3.33333	409.359	0.00244284	0.00814281	0	0.42	1.4	140	1.139993101	
Total Hardness (as CaCO3) mg/l	300	0.00333	409.359	0.00244284	8.1428E-06	0	30	0.1	10	8.14281E-05	
Total Alkainities (as CaCO3) mg/l	300	0.00333	409.359	0.00244284	8.1428E-06	0	31	0.103333 333	10.33333 333	8.41423E-05	

O.C.P.s.

These questions were:

- What are the major pollutants of O.C.P.s?
- Which are the most vulnerable pollution and pollutants in these O.C.P.s?
- Are you directly or indirectly affected by this O.C.P. contamination and how?
- What's your opinion about the water quality of these O.C.P.s?
- Is this O.C.P. water worth drinking or not? If not, then why?
- Is it useable for domestic or agricultural or other purposes?
- Is this water that can create any skin or any other diseases to you?
- What kind of fishes are there?
- When the fishing activity becomes maximum?
- If any artificial breeding/ cultures are implemented in that O.C.P.s? If yes then, when and how?

On the basis of these questionnaires, this is got that fishing rate is much higher in these O.C.P.s and there are only naturally breed fishes by which local inhabitants can be able to get proper nutrients as well as money from it.

Table 7 and 8 and Figure 9 & 10 reflect that selected O.C.P.s' water is not suitable for direct use in drinking and domestic purposes as compared to the different types of drinking water standards in Raniganj coalfield, as per IS 10500: 1991 Drinking Water-Specification but the local people utilize the said water for their different activities like agricultural activity, fishing activity etc. (Figure 9). Palit *et al.,* (2018), have also reported that WQI values of Harabanga O.C.P. and Damalia O.C.P. that were 53.54 and 60.30 respectively denote poor water quality and that water was not suitable for drinking purposes but could be used for agricultural activities. Pal *et al.,* (2013) also assessed of limnology of O.C.P.s in the same coalfield and cited that O.C.P.s' water is suitable for irrigation, aquaculture as well as drinking purposes after an application of suitable water manage-

Table 4. Determination of Water Quality Index (WQI) of Damalia abandoned O.C.P. as IS 10500: 1991 Drinking Water-Specification

Parameters	Maximum permissible limit (as per ISI) Sn	1/Sn	Σ1/Sn	K=1/(Σ1/Sn)	$W_1 = K/S_n$	Ideal Value V0	Mean Conc. Value (Vn)	Vn/Sn	Vn/Sn× 100=Qn	WnQn	WQI
Turbidity NTU	5	0.2	409.359	0.00244284	0.00048857	0	0.001	0.0002	0.02	9.77137E-06	82.8558
Dissolved Solids mg/l	500	0.002	409.359	0.00244284	4.8857E-06	0	125	0.25	25	0.000122142	
PH. Value	8.5	0.11765	409.359	0.00244284	0.00028739	7	6.85	10	1000	0.287393219	
Oil and Grease mg/l	0.01	100	409.359	0.00244284	0.24428424	0	0.001	0.1	10	2.442842359	
Total residual chlorine mg/l	0.2	5	409.359	0.00244284	0.01221421	0	0	0	0	0	
Ammonical Nitrogen (as N) mg/l	0.1	10	409.359	0.00244284	0.02442842	0	3.24	32.4	3240	79.14809242	
Nitrite Nitrogen (as NO_2) mg/l	0.1	10	409.359	0.00244284	0.02442842	0	0	0	0	0	
Arsenic (as As) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Hexavalent Chromium (as Cr) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Copper (as Cu) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Cyanide (as CN) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Chloride (as Cl) mg/l	250	0.004	409.359	0.00244284	9.7714E-06	0	9	0.036	3.6	3.51769E-05	
Flouride (as F) mg/l	1.5	0.66667	409.359	0.00244284	0.00162856	0	0	0	0	0	
Sulphates (as SO_4) mg/l	150	0.00667	409.359	0.00244284	1.6286E-05	0	0	0	0	0	
Nitrates (as NO_3) mg/l	45	0.02222	409.359	0.00244284	5.4285E-05	0	0	0	0	0	
Phenolic Compounds (as C6H5OH) mg/l	0.005	200	409.359	0.00244284	0.48856847	0	0	0	0	0	
Iron (as Fe) mg/l	0.3	3.33333	409.359	0.00244284	0.00814281	0	0.36	1.2	120	0.977136943	
Total Hardness (as $CaCO_3$) mg/l	300	0.00333	409.359	0.00244284	8.1428E-06	0	25	0.08333 3333	8.33333 3333	6.78567E-05	
Total Alkainities (as $CaCO_3$) mg/l	300	0.00333	409.359	0.00244284	8.1428E-06	0	23	0.07666 6667	7.66666 6667	6.24282E-05	

Table 5. Determination of Water Quality Index (WQI) of Ratibati abandoned O.C.P. as IS 10500: 1991 Drinking Water-Specification

Parameters	Maximum permissible limit (as per ISI) Sn	1/Sn	Σ1/Sn	K=1/(Σ1/Sn)	W1= K/Sn	Ideal Value V0	Mean Conc. Value (Vn)	Vn/Sn	Vn/Sn× 100=Qn	WnQn	WQI
Turbidity NTU	5	0.2	409.359	0.00244284	0.00048857	0	0.015	0.003	0.3	0.000146571	92.9864
Dissolved Solids mg/l	500	0.002	409.359	0.00244284	4.8857E-06	0	135	0.27	27	0.000131913	
PH. Value	8.5	0.11765	409.359	0.00244284	0.00028739	7	6.96	2.66	266	0.076446596	
Oil and Grease mg/l	0.01	100	409.359	0.00244284	0.24428424	0	0.01	1	100	24.42842359	
Total residual chlorine mg/l	0.2	5	409.359	0.00244284	0.01221421	0	0	0	0	0	
Ammonical Nitrogen (as N) mg/l	0.1	10	409.359	0.00244284	0.02442842	0	2.77	27.7	2770	67.66673333	
Nitrite Nitrogen (as NO2) mg/l	0.1	10	409.359	0.00244284	0.02442842	0	0	0	0	0	
Arsenic (as As) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Hexavalent Chromium (as Cr) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Copper (as Cu) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Cyanide (as CN) mg/l	0.05	20	409.359	0.00244284	0.04885685	0	0	0	0	0	
Chloride (as Cl) mg/l	250	0.004	409.359	0.00244284	9.7714E-06	0	18	0.072	7.2	7.03539E-05	
Flouride (as F) mg/l	1.5	0.66667	409.359	0.00244284	0.00162856	0	0	0	0	0	
Sulphates (as SO_4) mg/l	150	0.00667	409.359	0.00244284	1.6286E-05	0	0	0	0	0	
Nitrates (as NO_3)mg/l	45	0.02222	409.359	0.00244284	5.4285E-05	0	0	0	0	0	
Phenolic Compounds (as C_6H_5OH) mg/l	0.005	200	409.359	0.00244284	0.48856847	0	0	0	0	0	
Iron (as Fe) mg/l	0.3	3.33333	409.359	0.00244284	0.00814281	0	0.3	1	100	0.814280786	
Total Hardness (as $CaCO_3$) mg/l	300	0.00333	409.359	0.00244284	8.1428E-06	0	32	0.10666 6667	10.6666 6667	8.68566E-05	
Total Alkainities (as $CaCO_3$) mg/l	300	0.00333	409.359	0.00244284	8.1428E-06	0	36	0.12	12	9.77137E-05	

ment practice.

Conclusion

Water is the most important and vital resource for every living organism in the world and maintaining a balanced ecology in-between economy and different developmental activities. In recent decades increase in agricultural activity for the rapid growth of population, unplanned urbanization and thoughtless industrialization require a huge quantity of water. But water source is declining day by day because of various reasons, chiefly rapid civilization. Thus to face the challenges an alternative water resource is indispensable. In this point of view, the present study is carried out. The outcome of this investigation that the selected O.C.P.s' water is not suitable for drinking and domestic purposes but it can be used for irrigation and agricultural activities. The study can also be useful to evolve suitable water treatment and sustainable management plans from the competent authority that are needed for the use of the said water in these mining areas.

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Conflict of Interest

There is no conflict of interest with the mine workers, farmers, villagers, Government and other authorities/ organizations.

Table 6. Determination the status of water quality status of 3 selected abandoned O.C.P.s.

Water Quality Index (WQI) developed by Brown *et al.*, 1972							
Water Quality Index	Remark	Harabanga O.C.P.	Remark	Damalia O.C.P.	Remark	Ratibati O.C.P.	Remark
0-25 26-50 51-75 76-100 >100	Excellent Good Poor Very Poor Unfit for consumption	90.32430761	very poor	92.9864	very poor	82.8558	very poor

Table 7. Voting through respondent using issues or problem related questioner regarding three selected abandoned O.C.P.s.

	Contamination	Water quality	Fishing activity	Agriculture activity	Domestic activity
Local People	4	3	5	5	1
Mining workers	4	4	4	4	2
Local administrator	4	5	4	4	0
Environmentalists	5	5	3	3	0
Policy makers	4	5	5	5	0
Researchers	5	5	4	4	0
Total response	26	27	25	25	3
%	25	25	24	24	3

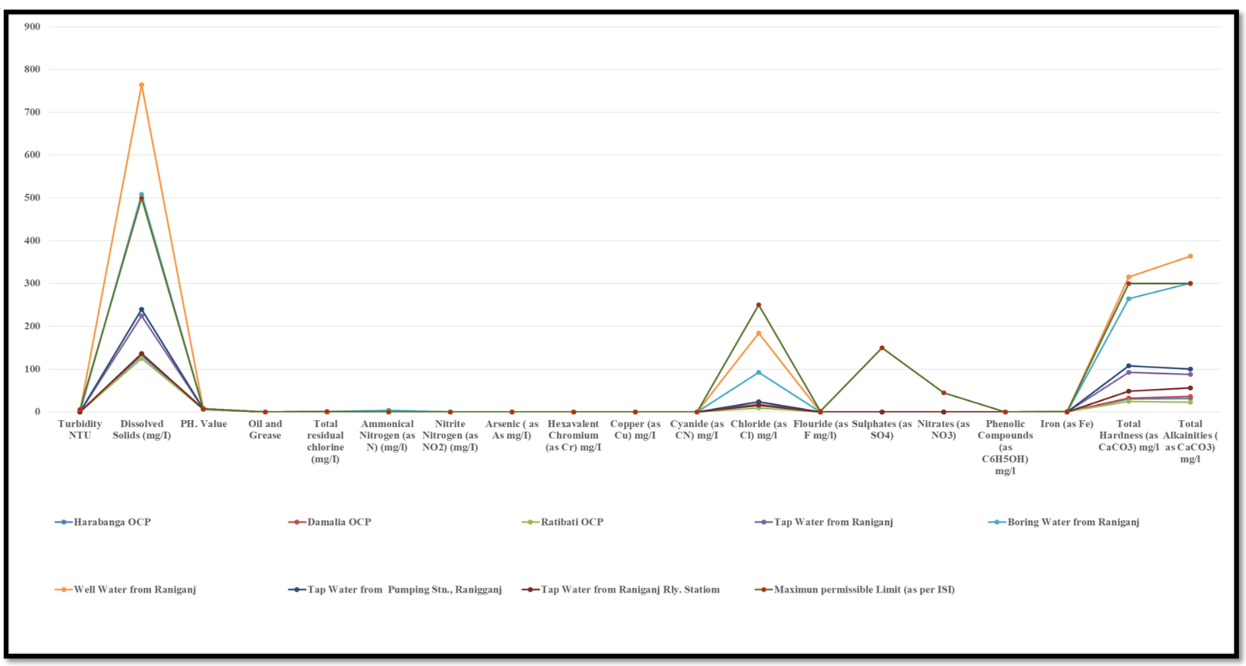

Fig. 10. Graph shows Comparison of selected three abandoned O.C.P.s water quality with different types of drinking water standards in Raniganj coalfield, as per IS 10500: 1991 Drinking Water-Specification

Table 8. Comparison of selected 3 abandoned O.C.P.s water quality with different types of drinking water standards in Raniganj coalfield, as per IS 10500: 1991 Drinking Water-Specification

Parameters	Harabanga O.C.P.	Damalia O.C.P.	Ratibati O.C.P.	Tap water from Raniganj	Boring water from Raniganj	Well water from Raniganj	Tap water from Pumping Stn., Raniganj	Tap water from Raniganj rly. station	Maximum permissible Limit (as per ISI)
Turbidity NTU	0.01	0.015	0.001	0	0	0.2	0	0.05	5
Dissolved Solids mg/l	132	135	125	224	508	764	240	136	500
PH. Value	6.78	6.96	6.85	7.26	7.08	7.79	7.16	6.56	7
Oil and Grease mg/l	0.01	0.01	0.001	0	0	0	0	0	0.01
Total residual chlorine mg/l	0	0	0	0.08	0.3	0.008	0.2	0.6	0.2
Ammonical Nitrogen (as N) mg/l	3.64	2.77	3.24	0	3.1	0.02	0	0	0.1
Nitrite Nitrogen (as NO_2) mg/l	0	0	0	0	0	0	0	0	0.1
Arsenic (as As) mg/l	0	0	0	0	0	0	0	0	0.05
Hexavalent Chromium (as Cr) mg/I	0	0	0	0	0	0	0	0	0.05
Copper (as Cu) mg/l	0	0	0	0	0	0	0	0	0.05
Cyanide (as CN) mg/l	0	0	0	0	0	0	0	0	0.05
Chloride (as Cl) mg/l	15	18	9	24	92	184	24	16	250
Flouride (as F) mg/l	0	0	0	0	0	0	0	0	1.5
Sulphates (as SO_4)mg/l	0	0	0	0	0	0	0	0	150
Nitrates (as NO_3)mg/l	0	0	0	0	0	0	0	0	45
Phenolic Compounds (as C_6H_5OH) mg/l	0	0	0	0	0	0	0	0	0.005
Iron (as Fe) mg/l	0.42	0.3	0.36	0	0	0	0	0	0.3
Total Hardness (as $CaCO_3$) mg/l	30	32	25	92	264	315	108	48	300
Total Alkainities (as $CaCO_3$) mg/l	31	36	23	88	301	364	100	56	300

Table 9. ANOVA on water qualitycomparison in-between selected 3 abandoned O.C.P.s and different types of drinking water standards in Raniganj coalfield

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	111170	7	15881.5	1.73526	0.10574	2.07755817
Within Groups	1244700	136	9152.21			
Total	1355871	143				

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