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Thermal and Heavy Metal Ions Pollution Assessment in Near By Water Bodies of Vijayawada Thermal Power Station

Y. HANUMANTHA RAO[1] and K. RAVINDHRANATH[2,*]

[1]Andhra Loyola College (Autonomous), Vijayawada-520 008, India
[2]Department of Engineering Chemistry and Post Graduate Chemistry, Bapatla Engineering College, Bapatla-522 010, India

*Corresponding author: E-mail: ravindhranath.sita@yahoo.com

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A thorough study is made to assess the thermal and metallic ion pollution caused by Vijayawada thermal power station in the surrounding water bodies. Surface and ground water samples at judicially chosen sample stations have been analyzed at specific intervals of time for a period of nine months. It is found that the surface and ground waters are being contaminated with respect to heavy metal ions. Stratification of impounded waters of Krishna river at the point of discharge of effluents, is observed due to elevated temperatures and it is resulting in the depletion of dissolved oxygen content and thereby causing stress on biota of the lake; valuable fish species are being disappeared from placid waters of Krishna river and causing the migration of fisher man for their lively hood. Further, it is observed that heavy metal ions like Cr, Mn, Fe, Ni, Cu and Zn are being leached from fly ash due to the anaerobic conditions prevailing in the bottom of stratified pond waters. The accumulation of these ions due to bio-amplifications signals the alarming situation ahead for the people in five costal districts in Andhra Pradesh as the same impounding waters are being supplied for their drinking and agricultural purposes.

Key Words: Vijayawada thermal power station, Depletion of DO, Thermal and metallic ion pollution.

INTRODUCTION

Thermal power is emerging as the major source of electric power in India and is expected to rise further[1-3]. It requires various natural resources like, fossil fuels and water. The environmental effects of thermal power generation are becoming a major concern[4-6]. Fly ash generated in the thermal power plants and its leaches are adversely effecting the water eco systems[7-16]. Thermal pollution is another consequence of power plant effluents and is threatening the aquatic life[17-19]. Any callous attitude on the part of the managing and controlling authorities of the power plant, create impacts on the environment and generate a stress in the local eco systems[20-22].

Although stringent norms have been made by the regulatory agencies to control and mitigate the damages cost to the environment by the power plants, the efficiency of implementation of the regulatory measures, turns to be "bane" to the habitation[3,18,23-25]. So, it is very appropriate to initiate studies in all thermal power stations throughout India to keep a check on ground water quality as well as surface waters to know whether the quality of water bodies are fulfilling the requirements of environmental protection laws or not and if not, what are the controlling measures to be adopted[4,26-30].

In this contest, Vijayawada thermal power station (VTPS) established at Ibrahimpatnam of Vijayawda rural area in Andhra Prades is interesting on three major points:

• The hot effluents of Vijayawada thermal power station are being merged into the lake waters of Prakasham barrage from where the water is drawn for meeting the water requirements of the Vijayawada thermal power station and also from the lake, originate three important canals namely, Eluru, Bandar and Bhakimham canal which are catering water needs of people of five costal districts of Andhra Pradesh and any pollution of the lake waters of the barrage, effect the "wealth and health" of the people. In thermal power stations effluents are generally, let into Seas or in the downward side of the river[31,29] but in the case of Vijayawada thermal power station, contrary to the general practice, the up taking waters are from the lake waters of the barrage and effluents are let into the same waters on upside of the river. As the waters are stagnated, this results in the accumulation of impurities especially of non-degradable impurities.

• The saline and beautiful greenery of Ibrahimpatnam surroundings of Vijayawada rural area before establishing the Vijayawada thermal power station, has slowly been disappeared with the time resulting in dry and desperate environment and there is a great public mummer turned into huge cry in this spirited and busy city of Vijyawada with regard to the visible pollution caused by fly ash coming out of chimney along with plumes and dusting the nearby fields to a large extents. Further, alarming situation is that fly ash containing toxic elements in one way or other finding its destination into the lake waters.

• The temperature of the effluents is almost nearly 10 ºC more than the room temperature resulting thermal stratification of lake, decrease of dissolved oxygen and the subsequent loss of ecological balance due to thermal stress. In fact even animals are hesitating to get into the placid waters of Krishna River to get themselves freshen.

In view of these, an effort is made in this work to assess the impact of effluents from Vijaywada thermal power station on the quality of water bodies of the surrounding areas of Vijayawada thermal power station with respect to thermal and metal ions pollution by analyzing the water samples pertaining to surface and ground waters.

EXPERIMENTAL

Vijayawada thermal power station is located at Ibrahimpatnam, 17 km away from Vijayawada railway station in Andhra Pradesh. The Vijayawada city is located on the west Bank of Krishna river and the said river turns towards north a few kilometers away from Vijayawada town and thereby provides ample space for building a pond. So, the well known Civil Engineer Dr. K. L. Rao constructed the famous Prakasam Barrage and thereby stagnating about 2TMC of water (Fig. 1).

Fig. 1. Prakasham Barrage

Fig. 2. Canals derived from Praksham barrage

From this diverting barrage three main canals were dug namely Bandar canal, Eluru canal and Buckingham canal. These canals are meeting the agricultural and drinking water demands of five coastal districts of Andhra Pradesh *i.e.*, West Godavari, Krishna, Guntur, Prakasham and some parts of Nellore. Thus the wealth and health of these districts depends upon the stagnating waters and water levels at Prakasam barrage.

Vijayawada thermal power station (VTPS) comprising of 6 units of 210 MW was developed in 3 stages; first stage units in 1979-80; second stage units in 1989-90 and third stage units in 1994-95. The water requirements for the thermal power station are met from the stagnated placid waters of the barrage and after the waters being used for different purposes of the thermal power station, it is let into the "same stagnated pool" of Krishna river (Fig. 4).

Fig. 3. Vijayawada thermal power station and environs

A canal of dimensions 24 m length × 15 m breadth (average) × 3 m depth is being used to take the impounding waters at the barrage from Bhavanipuram intake point 12 km away from the Vijayawada thermal power station (Fig. 4). The water after being used for various purposes in Vijayawada thermal power station , is let into the impounding waters of the Prakasam Barrage through Bhudameru canal of dimensions of 98m length × 82 m breadth (average) × 4 m depth at Tummalapalem (Fig. 4). The distance between Bhavanipuram intake point and the point of merging at Tummalapalem is 12 km and the later is on the upper stream side of the Krishna river. As the effluents are discharged into the same impounding waters of Prakasham

Fig. 4. Over view of the in-taking and out letting water of Vijayawada thermal power station

barrage, impurities especially of non-degradable nature *viz*., metal ions, get accumulated with time and they may reach threshold values in due curse endangering the aquatic life and also the people in five districts who depend upon this barrage waters.

Establishment of sample stations: In the present investigations three surface water stations as earmarked in the Fig. 5 were established: one at Bhavanipuram intake point: Station No. 1; other at outlet of the Vijayawada thermal power station into Budameru canal at Ibrahimpatnam: Station No. 2 and the other at Tummalapalem at which the outlet water is merging with Krishna River: Station No. 3.

Further it is endeavored to study ground waters also to understand whether any leaches in the ash pond causes the ground water contamination. Four stations were established; one at Tummalapalem: Station No. 4; other at Ferri: Station No. 5; other at Jupudi village: Station No. 6 and another at Seventh Day Adventure School: Station No. 7.

Further, four more sampling station Nos. 8, 9, 10 and 11 were established right in the Krishna waters (Lake) around the Vijayawada thermal power station effluent merging point at Tummalapalem in addition to the surface station Nos. 1,2 and 3. These stations were established at four equidistant points on the sectors at 50, 100, 150 and 200 m, respectively from the point of discharge of effluents from Vijayawada thermal power station in Krishna River waters at Tummalapalem.

Surface waters: By using 'sample thief' of capacity 2 L, the samples were collected at the top, bottom and middle depths at the sample stations. The samples in pond waters were collected and used for analysis.

Ground water: At sample stations 4, 5, 6 and 7 ground waters were collected from bore wells which were laid at depth of 60 ft.

Thermal pollution measurements: *In situ* measurement of temperatures at the surface stations *viz*., 1-3 and 8-11 using precise and accurate thermometers were made. At station Nos. 8-11, by rowing into the waters of Krishna river with the help of a country boat, the temperature measurements were made at three chosen points on each Sectors; one normal to the Krishna river bank and other two at an angle of 45° in clock wise and anticlockwise directions to the normal or bank.

The DO in the water samples were determined by Winkler's method[30,32-34].

The water samples were analyzed after concentration for Fe, Mn, Cr, Ni, Zn and Cu using GBC AVANTA (version 1.32) FLAME 1 atomic absorption spectrometer using the procedures as enlisted in the instrument manual[30,32].

RESULTS AND DISCUSSION

The observations made with respect to temperature and DO variations and concentrations of metal ions-during the period: April 10 to Dec. 10 were presented in the Tables 1-4.

Thermal pollution: Thermal pollution can occur when water being used as a coolant in a power plant, is returned to the aquatic environment at a higher temperature than it is originally. Thermal pollution leads to a decrease in the dissolved oxygen level in the water while also increasing the biological demand of aquatic organisms for oxygen. Hence, in this work a systematic effort was made to understand the temperature and DO variations with respect to season and at different stations. DO measurements were made for all stations while the temperature measurements were made only to the surface stations.

Salient observations

With respect to temperature

At any point of time, the temperature of the out let (effluent) waters from Vijayawada thermal power station either at station No. 2 or at station No. 3 are always nearly 7-12 ºC more than the temp of in taking waters at station No. 1 (Table-1: items: 1-3).

Even lake waters of Krishna river are not decreasing rapidly the content of heat in the waste waters of Vijayawada thermal power station and it is attributed to the fact that merging waste waters are huge in quantity and so, the temperatures are not coming to the normal quickly. For example, at the sectors at 50, 100, 150 and 200 m away from merging point, the average temps. of mixed Krishna waters were 49.2, 45.2, 42.2 and 41.2 ºC, respectively in the month of April.; 54.3, 52.4, 51.2 and 48.4 ºC in the month of May; 48.2, 46.3 , 44.4 and 43.5 ºC in the month of June; 47.2, 45.0, 43.0 and 39.9 ºC in the month July; 45.3, 42.3, 40.0 and 37.3 ºC in the month of August; 44.1, 39.1, 35.0 and 32.8 ºC in the month of Sept.; 37.2, 34.1, 31.0 and 28.3 ºC in the month of Oct.; 34.3, 31.3, 28.3 and 26.5 ºC in the month of Nov.; 34.4, 30.3, 27.6 and 25.5 ºC in the month of Dec. (Table-2: sample station Nos. 8, 9,10 and 11).

On comparison of the data in at station No. 1 and station No. 11, it is inferred that the mixed waters are coming nearly to the normal temperature only 200 m away from the effluent discharging point.

It is an interesting observation that in the surrounding area of water column around the station No. 3 extending to about 200 m, scanty is the aquatic life found.

With respect to dissolved oxygen content

There is a marked depletion of DO content in the samples stations located around the effluent merging point at Tummalapalem, *viz*., 8-11 in lake waters of Krishna river. The average values ranges from 1.7-2.7 at station No. 8; 1.7-2.9 at

TABLE-1
VARIATION OF TEMPERATURES

Item no	Sample station Nos.		Temperature (°C)								
			April 10	May 10	June 10	July 10	August 10	Sept 10	Oct 10	Nov 10	Dec 10
1	Surface waters	1	41.1	48.2	43.3	39.2	37.2	32.2	28.1	25.2	24.3
2		2	53.1	58.2	55.2	51.2	49.2	44.3	40.3	37.1	36.2
3		3	52.1	56	50.1	48.3	48.1	43.1	39.1	36.5	35.5

TABLE-2
TEMPERATURE VARIATIONS IN KRISHNA RIVER ARROUND THE ELLUENT MERGING POINT AT TUMMALAPALEM SAMPLE STATION NO. 3

Sample station Nos.	Location		Temperature (°C)								
	Sector	Point on the sector w.r.t. Krishna bank	April 10	May 10	June 10	July 10	Augt 10	Sept.10	Oct 10	Nov 10	Dec 10
8	50 m away from station No. 3	Normal	49.2	54.3	48.2	47.1	45.3	41.1	37.1	34.4	34.3
		45° clock wise	49.3	54.2	48.2	47.2	45.2	41.0	37	34.3	34.2
		45° anti clock wise	49.1	54.1	48	47.3	45.1	41.2	37.3	34.4	34.4
		Average temp.	49.2	54.3	48.2	47.2	45.3	44.1	37.2	34.3	34.4
9	100 m away from station No. 3	Normal	45.2	52.4	46.3	45.1	42.3	39.2	34.2	31.3	30.3
		45° clock wise	45.1	52.3	46.2	45	42.2	39.1	34.1	31.2	30.2
		45° anti clock wise	45.3	52.1	46	44.9	42.1	39	34	31.1	30.1
		Average temp.	45.2	52.4	46.3	45	42.3	39.1	34.1	31.3	30.3
10	150 meters away from station no. 3	Normal	42.2	51.2	44.5	43.1	40.1	35.1	31.1	28.4	27.5
		45° clock wise	42.1	51.1	44.4	43.0	40.0	35.0	31.0	28.3	27.4
		45° anti clock wise	42.0	51.0	44.3	42.9	39.9	34.9	31.0	28.2	27.3
		Average temp.	42.2	51.2	44.4	43.0	40.0	35.0	31.0	28.3	27.6
11	200 m away from station No. 3	Normal	41.1	48.4	43.5	40.0	37.4	32.9	28.5	26.6	25.6
		45° clock wise	41.3	48.3	43.4	39.8	37.2	32.7	28.3	26.4	25.4
		45° anti clock wise	41.2	48.5	43.6	39.9	37.3	32.8	28.2	26.5	25.5
		Average temp.	41.2	48.4	43.5	39.9	37.3	32.8	28.3	26.5	25.5

TABLE-3
VARIATION OF DISSOLVED OXYGEN (DO) IN SURFACE AND GROUND WATERS

Item No.	Sample station Nos.		Dissolved oxygen (ppm)								
			April 08	May 08	June 08	July 08	August 08	Sept 08	Oct 08	Nov 08	Dec 08
1	Surface waters	1	5.5	5.8	4.9	4.8	5.2	5.5	5.8	5.6	5.6
2		2	3.7	3.8	3.9	4.0	4.2	4.3	4.3	4.4	4.4
3		3	3.8	3.9	4.1	4.2	4.2	4.4	4.4	4.5	4.5
4	Ground waters	4	2.1	2.2	2.5	2.3	2.4	2.9	3.0	2.4	2.5
5		5	2.3	3.1	2.7	2.9	3.1	3.2	3.6	2.5	2.9
6		6	3.3	3.1	2.1	3.2	3.4	3.3	3.9	2.6	2.4
7		7	3.1	3.3	2.3	3.4	2.6	3.4	4.0	3.1	2.3

TABLE-4
VARIATION OF DISSOLVED OXYGEN (DO) AT STATIONS LOCATED IN KRISHNA RIVER AROUND THE MERGING POINT OF EFFLUENTS AT TUMMALAPALEM

Sample station Nos.	Location		Dissolved oxygen (ppm)								
	Sector	Point on the sector w.r.t. Krishna bank	April 10	May 10	June 10	July 10	Augt 10	Sept. 10	Oct 10	Nov 10	Dec 10
8	50 m away from station No. 3	Normal	1.4	1.3	2.1	2.4	3.1	2.4	3.1	1.9	2.1
		45° clock wise	1.8	2.0	1.9	2.6	2.5	2.6	3.2	2.1	2.4
		45° anti clock wise	1.9	1.8	2.3	2.8	2.6	1.9	3.4	2.3	2.5
		Average do	1.7	1.7	2.1	2.6	2.7	2.3	3.2	2.1	2.3
9	100 m away from station No. 3	Normal	1.6	1.4	2.5	2.6	3.2	2.8	3.2	2.4	2.6
		45° clock wise	1.7	1.6	2.3	2.7	2.8	2.7	3.3	2.8	2.7
		45° anti clock wise	1.9	2.1	2.6	2.9	2.8	2.9	3.4	2.9	2.8
		Average do	1.7	1.7	2.5	2.7	2.9	2.8	3.3	2.7	2.7
10	150 m away from station No. 3	Normal	1.9	1.8	2.6	2.8	3.3	3.1	2.9	3.0	2.3
		45° clock wise	2.1	1.7	2.5	3.0	3.0	3.0	3.1	2.9	2.5
		45° anti clock wise	2.3	2.4	2.7	3.1	3.0	2.9	3.1	2.9	2.7
		Average temp.	2.1	2.0	2.6	3.0	3.1	3.0	3.0	2.9	2.5
11	200 m away from station No. 3	Normal	3.1	2.9	2.7	3.0	3.1	3.2	3.3	3.1	2.4
		45° clock wise	3.3	3.1	2.8	2.9	3.1	3.3	3.4	3.0	2.6
		45° anti clock wise	3.4	3.1	2.9	2.9	3.2	3.4	3.6	3.2	2.8
		Average temp.	3.3	3.0	2.8	2.9	3.1	3.3	3.4	3.1	2.6

station No. 9; 2.0-3.1 at station No. 10 and 2.6-3.4 at station No. 11 during the period of study (Table-4).

The DO content is found to be less in the surface samples station 2 and 3 in comparison with intake waters at station No. 1 at any point of time (Table-3: item Nos. 1-3).

In the case of ground waters, DO was found to be changed from 2.1-3.1 ppm for the stations 4-7 in the month of April 10 and the same trend was observed in the remaining months (Table-3: item Nos. 4-7).

The data indicates that thermal pollution and consequence depletion of dissolved oxygen content are occurring in the nearby water bodies. The heat content in the huge amounts of discharging waters is not being brought to the room temperature even by the Krishna lake waters. Only at about 200 m away from the merging point, the temperature of the waters coming to the normal. This slow dissipation of temperature is resulting in the thermal pollution at least in a sector of water column around the Tummalapalem discharging point which extends to about 200 m from the station No. 3. This results in the Stratification of layers and subsequent pond ecological imbalance and endangering the aquatic life. The warmer water temperatures causing the stratification of layers around the discharging point is depicted in Fig. 5.

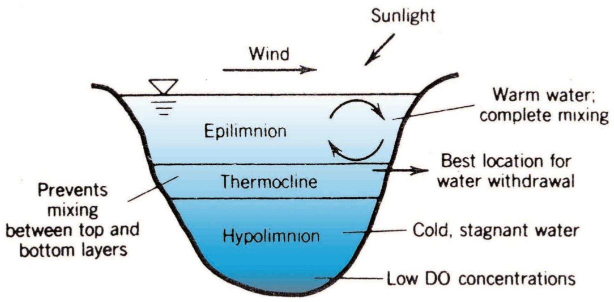

Fig. 5. Summer stratification near discharing point of hot effluents from Vijayawada thermal power station into Krishna river Water: at S3, S8 to S11

Due to the mixing of hot water into layers and persistent elevated temperature, for long periods, the density of the surface layers of water is less than in the bottom layers and there will not be any conventional mixing. This results in thermal stratification layer. The warmer top layers formed are called "epilimnion" and cold and denser water layers in the bottom of the lake, are called "hypolimnion". A relatively thin layer of water with rapidly decrease in temp from top to bottom called "thermocline" separates the epilimnion and hypolimnion as shown in the Fig. 6. The "thermocline" acts as a physical barrier which prevents the mixing of water between top and bottom layer of the lake. "Thermoclinle" acts as armor for aquatic life from the thermal stress caused by the thermal station out flowed waters and is similar to that of ozone layer protection on earth for human life from the attack of electromagnetic radiation.

This problem of stratification is more felt in the summer than the other seasons when the rate of cooling of hot waters is rather slow. This stratification layers and depletion in DO content causing stress on biota and other aquatic life. The elevated temp in surface waters not only decreases DO content but also increases the rate of metabolism of fish and thereby causing the changes in the ecological balance in the river. Oxygen is only slightly soluble in water (9 ppm at 20 ºC) and this small amount of oxygen sustains the huge aquatic life which is a many folds greater than the life on earth. Because of this very slight solubility, there is usually quite a bit of competition among aquatic organisms, including bacteria, for the available dissolved oxygen. Bacteria will use up the DO very rapidly if there is much organic material in the water. At elevated temperature the availability of DO is less and need for metabolism is more and this results in loss of ecological balance and valuable fish species. It is a common feature here to view in summer seasons when significant population of died fish floating bally up in the river and washed up along the shores.

Our interaction with the fisher men revealed that they are quite unhappy both with the catch and variety of aquatic life and in fact most valuable fish species disappeared from the Krishna waters at the Thummalpalem surroundings due to the stress caused by the depletion of oxygen content and increase of temperature and majority of fisher men migrated away from this locality for their lively hood. Thus the Vijayawada thermal power station started the cleaning effect of the biota and other aquatic life of Krishna river waters!?.

Hence, adequate measures are to be taken by Vijayawada thermal power station in sufficiently cooling the discharging waters from the thermal stations such that the aquatic life and other biota is allowed to be sustained. For this dissipation of heat into the atmosphere, cooling towers and cooling ponds are to be established following standard measures and are to be properly maintained as shown in the Fig. 6.

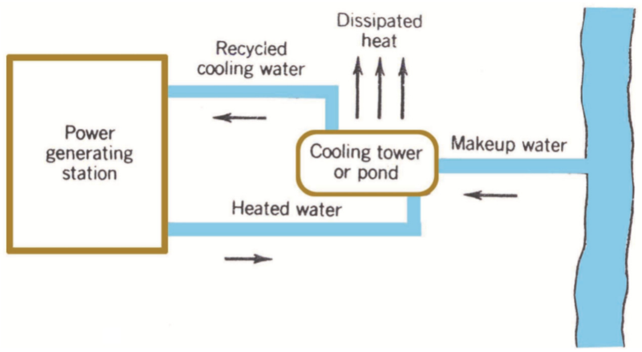

Fig. 6. Thermal pollution from Vijayawada thermal power station can be eliminated by using recycled cooling towers of ponds

It is surprising that even when all these measures are said to be taken by the Vijayawada thermal power station authorities, the waters possess higher heat content and have elevated temperatures and are not congenial to aquatic life. This fact may be due to the procedural lapses in maintaining and monitoring the different aspects of the cooling mechanisms. Hence, proper care is to be bestowed by the Vijayawada thermal power station authorities to cool the waters to room temperature before letting the waters into river or otherwise a great environmental offence is perpetuated inadvertently.

Heavy metal ions: The observations made with respect to different heavy metal ions are as follows:

Zinc: (Graph 1): The concentration of zinc varied from 0.015-0.024 ppm at the station No. 1, 0.025-0.043 ppm at the station No. 2 and 0.028-0.048 ppm at the station No. 3 during the period of study April 10 to Dec. 10.

The out letting surface waters from Vijayawada thermal power station showed more concentration of zinc at the sample stations 2 and 3 than the in taking waters at the sample station 1. For example in the month of April 10, the conc. of zinc at the station 1 was found to be 0.022 ppm while at the station 2 and 3, the conc. of zinc was found to be 0.036 and 0.038 ppm respectively. The trend was found to be same in other periods of the study.

The ground waters showed more conc. of zinc than the surface waters. Zinc was found to be between 0.12-0.17 ppm, 0.11-0.18 ppm, 0.208-0.29 ppm and 0.218-0.31 ppm at the stations 4, 5, 6 and 7, respectively during the period April 10 to Dec. 10.

The ground water at the stations 6 and 7 showed more amounts of zinc than at 4 and 5 stations. For example in the month of April, the zinc was found to be 0.12 ppm at the station No. 4 and 0.11 ppm at the station No. 5 while the conc. was found to be 0.24 at station No. 6 and 0.28 at station No. 7. Similar trend was found in the said period of study at the ground water stations.

Sample station 8-11 in Krishna river, also show enriched conc. of Zn.

From the above observations, it can be inferred that the out letting waters of Vijayawada thermal power station have more conc. of Zinc than in taking waters and further, high conc. of zinc were found in the ground water samples.

Copper (Graph 2): The content of copper was found to vary from 0.08-0.17 ppm at the surface water station No. 1; from 0.19-0.29 ppm at the station No. 2; from 0.20-0.30 ppm at the station No. 3 during the period of study *i.e.*, from April 10 to Dec. 10.

In ground waters, the conc. of copper was found to be varied from 0.34-0.42 ppm at station No. 4, from 0.37-0.49 ppm at the station No. 5, 0.48-0.59 ppm at the station No. 6 and 0.54-0.68 at the station No. 7 during the said period of study. The ground waters were found to be more polluted than the surface water with respect of copper. Further, the samples at the station Nos. 6 and 7 were found to be relatively more polluted than the samples at station Nos. 4 and 5. The effluent waters from Vijayawada thermal power station at the station Nos. 2 and 3 and sample waters at stations 8-11, were found to have more content of copper than at the in taking water station No. 1.

The values show that Vijayawada thermal power station is causing the accumulation of copper in surface waters as well as in ground waters.

Nickle (Graph No. 3): The content of nickel in the surface water stations was found to be between 0.0075 and 0.0095 ppm at the station 1; 0.009 ppm and 0.014 ppm at the station 2; 0.0088 ppm and 0.013 at the station 3 for the period of study, April 10 to Dec. 10.

The nickel concentration was found to be more in stations 2, 3 and 8-11, than in taking water station 1. As for example, in the month of April, the concentration of nickel at the station No. 1was found to be 0.0095 ppm while the concentration was found to be 0.011 and 0.012 ppm, respectively at the stations 2 and 3. The water samples of ground water sample stations 4-7 showed more content of nickel than waters of surface water stations 1-3 and 8-11. The ground water samples at the station Nos. 6 and 7 showed relatively more concentration of Nickel than at station Nos. 4 and 5.

From the above observations, it may be inferred that the Vijayawada thermal power station is causing pollution of surface as well as ground waters. The increasing tendency of the values indicates that the waters are at the verge of potential nickel pollution.

Iron (Graph No. 4): During the period from April 10 to Dec. 10, the content of iron varied from 0.43-0.82 ppm at the surface water station 1; from 0.65-0.92 ppm at the station 2; from 0.53-0.90 ppm at the station 3; 0.81-1.20 ppm at station 8; 0.75-1.05 ppm at station 9; 0.72-0.94 ppm at station 10; 0.69-0.91 ppm at station 11.

In ground waters, the conc. of iron varied from 0.76-1.4 ppm at station No. 4, from 1.0-1.5 ppm at the station No. 5, 1.2-1.59 ppm at the station No. 6 and 1.4 to 1.8 ppm at the station No. 7 during the period of study. The ground waters were found to be more polluted than the surface water with respect to iron. Further, the samples at the stations 6 and 7 were found to be relatively more polluted than 4 and 5 stations. The out letting water from Vijayawada thermal power station at the station Nos. 2 and 3 have more content of iron than in the in-taking water sample at station No. 1.

Hence, Vijayawada thermal power station is contaminating the near by water bodies with respect to the content of iron.

Manganese (Graph No. 5): The content of manganese varied from 0.029-0.051 ppm at the surface water station No. 1; from 0.132-0.156 ppm at the station No. 2; from 0.137-0.152 ppm at the station No. 3 during the period of study *i.e.*, from April 10 to Dec. 10. In ground waters, the conc. of manganese varied from 0.157-0.183 at station No. 4, from 0.159-0.188 ppm at the station No. 5, 0.184-0.241 ppm at the station No. 6 and 0.196-0.256 ppm at the station No. 7 during the period of study. The ground waters were found to be more polluted than the surface water with respect of manganese. Further, the samples at the station Nos. 6 and 7 were found to be relatively more polluted than 4 and 5 stations.

The out letting water from Vijayawada thermal power station at the station Nos. 2 and 3 and sample waters at station Nos. 8-11, were found to contain more content of manganese than at the in-taking water station No. 1. For example, in the month of April the concentration of manganese was found to be 0.048 ppm at station No. 1 while the concentration of manganese was found to be 0.139, 0.137, 0.165, 0.159, 0.149 and 0.130 ppm at the station Nos. 2-4 and 8-11, respectively. The trend persisted in the other periods of investigation.

The results indicate that the Vijayawada thermal power station is causing the accumulation of manganese in surface waters as well as in ground water.

Chromium (Graph No. 6): During the period of April 10 to Dec. 10, the content of chromium in the surface water station No. 1 was found to be between 0.002-0.0030 ppm; from 0.0035-0.0048 ppm at the station No. 2; from 0.0032-0.0045 ppm at the station No. 3. In ground waters, the conc. of chromium was found be varied from 0.0064-0.0080 at station No. 4, from 0.0074-0.0092 ppm at the station No. 5, 0.0079-0.0095 ppm at the station No. 6 and 0.0082-0.0098 ppm at the station No. 7 during the period of study. At the sample stations in pond, the chromium conc. varied from 0.0034-0.0045 ppm at sample station 8; 0.0022-0.0039 ppm at sample station 9; 0.0014-0.0021 ppm at sample station 10 and 0.001-0.0016 ppm at sample station 11, respectively. The ground waters were found to be more polluted than the surface water with respect to chromium. Further, the samples at the station No. 6 and 7 were found to be relatively more polluted than 4 and 5 stations. The out letting water from Vijayawada thermal power station at the station Nos. 2 and 3 were found to have more content of chromium than at the in taking water station No. 1. For example, in the month of April 10, the concentration of chromium was found to be 0.0029 ppm at station No. 1 while the concentration of chromium was found to be 0.0043 and 0.0042 ppm at the station Nos. 3 and 4, respectively. The same trend persisted in the other periods of investigation also.

These observations indicate that Vijayawada thermal power station is causing chromium pollution in surrounding water bodies.

From these observations, it may be inferred that Vijayawada thermal power station is slowly contributing to Zn, Cu, Ni, Fe, Cr pollution in ground waters as well as in surface water. In fact these ions are in the fly ash and are being leached into water bodies and ground waters[22,35]. Moreover, the thermal pollution is causing the stratification of lake waters at the Tummalapalem effluent discharge point to an extent of 200 m and subsequently the depletion of dissolved oxygen is found to occur resulting anaerobic conditions especially prevailing in the bottom of the pond; these anaerobic conditions are found to leach of metal ions from the deposited fly ash.

The observation with respect to Cr and Ni is alarming as they are very dangerous ions and their accumulation in the nearby water bodies(both surface and ground waters) may turn to be detrimental to the habitation survival.

Conclusion

The present study indicates that the Vijayawada thermal power station supposed to be modern temple of human civilization is turning into the threat to environment and endangering the lives of the people dwelling in the nearby areas.

Vijayawada thermal power station is causing both surface and ground water pollution. The peculiarity of the Vijayawada thermal power station at Vijayawada is that it is meeting its water needs from the stagnated Krishna waters of Prakashma barrage and effluents from the power station are let into to the same stagnated waters above the Prakasham barrage. Generally power station effluents are merged either into sea, or into the down waters of stream or river. But in this case, effluent waters are merged into the pond waters of Prakasahm barrage which is severing the water requirements of 5 districts through three major canals, *viz*., Eluru, Bandar and Bhakimham canals and for which the prosperity in this area is attributed. Any contamination of these waters leads in effecting the "health and wealth" of the people.

So, unless the purity of effluent waters is almost equal to that of in-taking waters, the effluent waters from Vijayawada thermal power station should not be allowed to mix because thus entered impurity into the stagnated waters get accumulated during the course of time and this is so, especially with respect to the non-degradable ions such as metal ions. Even a small enhancement of concentration of impurities in the effluent waters should not be tolerated.

The results of the present study showed that the effluent waters are not adequately been treated and the enrichment of metallic impurities in the effluents, signal the dangerous days of human threat ahead. The general argument that the concentration of some pollutants are within the limits of standard values at the time of emerging point from the Vijayawada thermal power station, is totally wrong in view of the fact that the effluents are being merged into the upstream of Prakashm barrage and not into down the stream and further, the waters are stationed waters and not running waters. The aquatic life *viz*;, fishes, phytoplankton in the lake magnifies the metal ions through the process called "Bio-Amplification" resulting in the further accumulation of metallic impurities and the ultimately, these impurities manifest into the health of the people who depends upon these lake (Prakasham Barrage) waters. This is an alarming situation.

At the merging point of effluents at Tummalapalem, we can see the settled deposits of fly ash of Vijayawada thermal power station. In other wards, the effluents of Budameru canal are serving as a means to bringing fly ashes of Vijayawada thermal power station to the Krishna water to the tranqilling and lucid waters of Prakashm barrage. The fact is even animals hesitating to get into the gifted waters of Krishna to get themselves freshen.

Further, it is found that in this study that stratification of layer is occurring around the effluent merging point at Tummalapaem in Krishna waters in an area extended to 200 m. The accumulating ash and subsequent leaching of metallic ions from it due to the anaerobic conditions prevail in the bottom of the pond as a result of stratification, are causing the threat to biota of the pond. The visible presence of fly ash around Vijayawada thermal power station is due to improper chimney construction and ill maintenance resulting the poor Plume dynamics and characteristics. The removal of dust from the chimney gases by mechanical dust collectors and electrostatic precipitators is of prime importance because continuous inhaling of dust causes chronic breathing trouble to the surrounding people and to that matter the animal life and plant life is also effected in the near by areas. In fact, before the Vijayawada thermal power station, the area surrounding the place is a pleasant sight of greenery and is endowed with rich plantation but now that glory has been lost and the green plants have been badly affected and nearby fields are covered with fly ash deposits (Fig. 3). Electricity is generated but at the cost of environmental purity and human health.

Thus, due to ill maintenance of Vijayawada thermal power station, the fly ash is falling in the nearby fields and due to rain run off, the ashes are being collected into the pond and thereby enriching the heavy metal ions due to the anaerobic conditions prevails at the bottom of the pond and thus enriched waters with metal ions, are being used for drinking and agricultural purpose by about people of 5 districts and finally this is resulting in the loss of health and wealth of the Lakhs of people. Power generation while sustaining the ecological balance is essential for prosperity of a habitation. The power plants should be boon to the people and not bane.

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