

**ASSESSMENT OF AIR AND WATER QUALITY  
IN OPENCAST MINES**

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF

**BACHELOR OF TECHNOLOGY  
IN  
MINING ENGINEERING**

BY

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DEPARTMENT OF MINING ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

ROURKELA – 769008

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UNDER THE GUIDANCE OF  
**Dr.B.K.PAL**



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# National Institute of Technology Rourkela

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## CERTIFICATE

This is to certify that the thesis entitled “**ASSESSMENT OF AIR AND WATER QUALITY IN OPENCAST MINES**” submitted by **Sri Rahul Pasayat and Sri Jiten Kumar Pal** in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela is an authentic work carried out by them under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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## **ABSTRACT:**

Mining Industry is one of the most important and revenue-generating industries of our country. It's pivotal for the industry to thrive and grow to ensure that the manufacturing sector also develops at the required pace. But the detrimental effects of mining are far more dangerous than we can perceive and must be kept under check to reduce the polluting consequences on environment. Mining of any ore leads to befoulment of water bodies and also air contamination.

The sources of air pollution in open cast mines are drilling and blasting of ore bodies, loading and haulage of blasted ore, handling of material and maintenance. The standards for air pollution have been set by National Ambient Air Quality Standards(NAAQS) and it's based on criteria like  $PM_{2.5}$ ,  $PM_{10}$ , SPM etc.  $PM_{2.5}$  and  $PM_{10}$  are the standards acceptable for respirable dust and pollutants.

The water that runs off the mines can have detrimental effect on the water bodies that are in and around the mining areas. The seepage from ore bodies, mining waste rocks and treatment of effluents pose a great threat to the water bodies and the aquatic life associated with them. This project will assess the various parameters of water that decide the pollution level of the water body and will also focus on the dependency of ore type on the pollution level of the water bodies.

## **SAMPLING:**

The samples were collected from 4 different mines of different ore types:

- Coal Mines- Samaleshwari OCP, MCL
- Iron Ore Mines- Kiriburu Iron Ore Mines, SAIL
- Limestone and Dolomite Mines- OCL, Rajgangpur
- Chromite Mines- Tata Steel, Sukinda

The samples were analysed through a series of physical and chemical tests like pH, DO, BOD, Chloride, Total Hardness, and other metal contamination. After finding out the parameters, the water quality of the mines was analysed and the correlation between the ore types and water pollutants were found out.

## OBSERVATIONS:

### Water Quality:

#### Physical Parameters:

Parameters-> Samples*	Temperature	TDS	Conductivity(in ms/cm)	Turbidity(in NTU)
s1-a	18.06	0.124	0.192	2.5
s1b	17.71	0.784	1.22	94.4
s2	20.2	58	0.62	12
s3-a	17.1	0.265	0.408	2.3
s3-b	18.81	0.323	0.505	3.5
s4	21.74	0.264	0.4	1.3

#### Chemical parameters:

Parameters-> Samples	pH	NO <sub>3</sub> <sup>-</sup>	DO(in mg/l)	DO%	BOD	ORP in mV
s1-a	7.4	3.99	14.01	152.7	2.6	300
s1b	5.36	4.43	13.32	144.7	2.3	170
s2	6.85	10.25	11.3	132.6	2.4	268
s3-a	5.72	0.9314	11.84	126.8	2	292
s3-b	5.52	1.2	10.8	119.6	2.2	306
s4	5.63	0.36	11.27	131.6	7.19	276

#### Metals Contamination:

Parameters-> Samples	Na <sup>+</sup>	K <sup>+</sup>	Cu <sup>2+</sup>	Fe <sup>2+</sup>	Zn <sup>2+</sup>	Ni <sup>2+</sup>	Pb <sup>2+</sup>	Hg <sup>+</sup>	Cr <sup>2+</sup>	As <sup>2+</sup>	Cd <sup>2+</sup>
s1-a	0.95	0.28	0.01	0.001	0.006	0.002	BDL	BDL	.001	.021	.005
s1b	1.29	5	0.008	0.082	0.107	0.155	BDL	BDL	.001	.026	.006
s2	0.27	6.11	0.01	0.1	0.002	0.012	BDL	BDL	0	0	0
s3-a	0.74	0.32	0.006	0.086	0	0.004	BDL	BDL	.001	.013	.004
s3-b	0.74	0.48	0.008	0.08	0.008	0	BDL	BDL	.002	.019	.006
s4	0.51	0.32	0.012	0.004	0.002	0	BDL	BDL	1.259	.042	.007

## Air Quality:

Parameters-> Samples*	PM 2.5	RSPM	NO <sub>x</sub>	SO <sub>2</sub>
s1	51	128	19	16
s2	60	103.6	13.15	9.86
s3	32	81	19.13	3.8
s4	37.44	66.38	11.59	4.51

## CONCLUSION:

Both the air and water quality assessment of the four mines gave encouraging results. While the results revealed that the levels are under permissible limits, yet they have the potential to be detrimental to the environment. The greater level of air quality control at TATA Steel sukinda mines exemplifies the fact that the other mines need better mitigation and prevention measures to control the dust and fumes in the air. Use of wet drilling and chemicals for dust control in haulage road can go a long way in ensuring that the air quality in mines and nearby regions are not harmful enough for the humans living and working nearby.

As far as the water quality is concerned, most of the mines have good quality of water. The chromite content in the sump water of Tata Steel is higher and must be treated properly before it is allowed to mix with any other water bodies. The pH of most of the samples were lower than 7 and can be alarming if the water happens to mingle with any other source of drinking water or ground water. The water from the mines should be preferably treated properly before being discharged.

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**LEGEND:**

RSPM	Respirable Dust Particulate Matter
PM	Particulate Matter
SAIL	Steel Authority of India Limited
KIOM	Kiriburu Iron Ore Mines
MCL	Mahanadi Coalfield Limited
OCL	Orissa Cement Limited
DO	Dissolved Oxygen
ORP	Oxygen Reduction Potential
AAS	Atomic Absorption Spectroscopy
NSF	National Sanitation Foundation
WQI	Water Quality Index

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Mining industry is one of the fastest growing industries in the country. The growth and development of this industry is a necessity considering the dependence of other sectors and industries on mining. Going by GDP, of both mining and the industrial sectors that are affected by it, the mining industry contributes a staggering 11%, as per the data for the FY 2011-12. With increase in the revenue generated, the mechanization in the industry has also gone up. The open cast mines which used to have manual labour are now either semi-mechanized or mechanized mines. The number of machines and the complexity of the machines used in the mines have gone up and this has had both positive and negative impacts. While the production rates have gone up due to increase in the mechanization, the levels of pollution owing to these machines can't be ignored. In this project, we have chosen open cast mines for analysis because the pollution level in open cast mines is greater compared to underground mines as it destroys the natural habitat and releases pollutants directly into the environment. The rehabilitation never completely re-establishes the environment in the natural state.

Air pollution in mines is caused by various operations that take place. The operation of face preparation is the most significant contributor of air pollutants in the mining environment. Operations like drilling, blasting, loading and unloading of ore & overburden, conveyance of ores, processing, crushing and other operations also disperse dust particles into air, most of which stay suspended in the air for a very long time, until and unless proper mitigation measures are taken. Apart from the dust, the diesel exhaust from the shovels, dumpers, graders, rock breakers, dozers also pollute the environment with pollutants like CO, CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub> etc. Researchers suggest that movement of HEMM can contribute up to 80% of respirable dust in the atmosphere. The National Ambient Air Quality Standard has laid down standards for dust content in the atmosphere in and around the mines, and the parameters include PM<sub>2.5</sub>, PM<sub>10</sub>, and other pollutants.

Water is the biggest casualty of mining industry. Water pollution is a cause of big concern throughout the world and the industry of mining poses a big threat towards all the water bodies that lie around a mine. The major contaminants of water in mines are the surface run off, the washing of machines, rain water that leaches the mining bodies, water that runs off spoil heaps, spoil heap failure and mingling with water bodies, acid mine drainage and

rebound of mine water. Sometimes the water from processing plants is also released to water bodies and it leads to serious pollution. This pollution leads to increase of chloride, sulphide, sulphate content in the water. Apart from salts, the heavy metal contamination is a big risk and it poses threat to all the aquatic animals. Iron, Copper, Zinc, Mercury, Cadmium, Arsenic, Lead are the most dangerous contaminants and if not controlled can lead to death of animals and human, on consumption.

Since the polluted water are detrimental to the flora and fauna associated with the water bodies, so it is important to study the parameters of water pollution and estimate the level of damage that a particular source of water can do. Moreover, the relation between a particular pollutant and the mined ore can help us study the effect of mining of any particular mineral type. If we can find the dependency of a metal contamination or pollutant on the mineral type, then we can easily associate the pollution types in future and it can help us assess the potential damage that any mining project can do.

#### OBJECTIVES OF THE STUDY:

1. To collect air and water samples from the 4 mines of different mineral type.
2. To analyse the air and water parameters of the mines.
3. To estimate the most polluting agent of each source and its possible cause.
4. To find the relation between pollutants and type of mineral that is mined.





The following is a brief review of scholarly work of different researchers in the field of Ambient Air Quality Assessment:

**Stein and Corn**(1975) collected air samples from the underground coal mines of Pittsburgh, Lower Freeport and Kittanning seams, using a horizontal elutriator and 8” x 10” membrane filters(Milliore SCW P00010). They found out that to give a clear idea on the physical nature of the size fractions, density, and particulate matter size by optical microscopy, the projected area and the specific surface area need to be provided. The samples were divided into 4 different fractional sizes by a centrifugal classifier (BAHCO). The aforementioned parameters were then discovered for each size fraction. Then the difference in parameters for different sizes was observed, analysed and discussed. Using the analysis on difference of size fraction, it was possible to analyse the relation of various size fraction with respirable lung diseases with the different size fractional properties of the ARD.

**Kumari et.al.** (1995) determined the presence of quartz in airborne respirable dust, which is known to be the main cause of cancer and silicosis. They used FTIR spectrometer, with direct on filter method for determining ARD with quartz doublet peak at 800 and 700  $\text{cm}^{-1}$ . Personal dust samplers were used to collect air samples from different locations and they were collected over GLA-5000 PVC membrane filters. Sources of dust generation were selected and dust samplers were stationed there. The mine workers who were indulged in shift work were attached with samplers. The findings of the experiment, conducted in both coal and metal mines were, quartz content is less than 1% of the prescribed maximum exposure limit of  $3\text{mg}/\text{m}^3$ , except for a few locations in Longwall and bunker top. Drilling, haulage and crushing are the main sources of siliceous dust and it is wet drilling that is required for improving the ventilation state and reducing the quantity of dust in air.

**Chaulya** (1999) conducted air quality assessment for one year in Lakhanpur mines. He discovered that the dust levels, the average concentrations of TSP and  $\text{PM}_{10}$  were higher than the prescribed limits of NAAQS. With the aid of a linear regression analysis, he predicted the

concentrations of a type of particulate matter by knowing the level of other. To evaluate the standard of air, stations with the purpose of monitoring were placed; sampling was done fortnightly in residential areas and six times monthly in industrial regions. The sampling was done from September 1998 to August 1999. He suggested optimizing the control measures at overburden dumps, excavation area and coal handling plant as a part of controlling the Total Suspended Particulate emissions. According to reports, Carbon Monoxide (CO) and Lead (Pb) emissions were below detectable limits and didn't pose any kind of threat.

**Kruppa and Legge** (1999) did extensive study on the usage of passive samplers for gaseous air pollutants. They studied their use and compared the results directly with co-located active samplers or continuous monitors, for the sake of accuracy. It was discovered that the season influenced the comparisons of data from passive sampling against active monitoring, especially in the cold climate. The differences between the 2 systems can be significantly high during the winter months. Pollutants like ammonia ( $\text{NH}_3$ ) must be transformed or converted to a secondary compound ( $\text{NO}_2$ ) before assessment. It can and does lead to technical absurdities while instrument is placed on site. Despite the desire to use these passive samplers, from economical and logistical point of view, they should be located parallelly with passive samplers, at the same location, with continuous monitors at sampling points.

**Ghose and Majee** (2001) noted that coal in India is mined out dominantly from opencast mines, leading to more than 70% of total coal output and it is also the leading contributor in air contamination. A test was conducted to take data, to note the pollution in the local air, and the readings obtained were analysed. They observed that the air contaminants are generated from mines and they had high potential to pollute the environment and cause serious health and respiratory ailments. The control measures, as mentioned in the report, suggested afforestation and reported trees as tolerators of dust particulate matter. Emphasizing the need of use of chemical to minimize air pollutants from haulage road, they vouched for a pollution free environment by implementation of suitable abatement measures.

**Chakraborty et al.** (2001) formulated an empirical method to calculate the rate of emission in various opencast mining projects. They conducted experiments in 7 coal mines and 3 iron

ore mines, while considering the geographical site, working techniques, accessibility and resource formation. While they developed a uniform formula for  $\text{NO}_x$  and  $\text{SO}_2$  emission estimation, they conceptualized 12 different formulas for suspended particulate matter for various activities and locations, like drilling, blasting, loading of coal, material handling, haulage, workshop, maintenance centres etc. To validate the formula and its results, Rajpura opencast coal mining project was selected and the accuracy level of calculated value vis-à-vis field value was between 77.2% to 80.4%. They deduced that suspended particulate matter is the leading constituent of emissions while  $\text{NO}_x$  and  $\text{SO}_2$  are not the main reasons of pollution and rather negligible contributors. The results of this study are pivotal for modelling and for technocrats working to monitor, control and prevent air pollution in mining and related fields.

**Reddy and Ruj** (2002) experiment in Raniganj-Asanasol area, assessing the ambient air quality based on sulphur dioxide,  $\text{NO}_x$ , SPM at 4 different sites- Raniganj Girls College, Searsol Raj high school, BB College and BC College. A total of 429 samples were taken each from RGC and SRS. A total of 435 samples were collected each from BBC and BCC location. Ambient air quality monitoring was done for 3x8 hours per day at each site, on alternate days and it continued for 1 years. Other parameters like temperature, relative humidity, air speed and direction were also recorded simultaneously. High volume samplers were used to measure SPM,  $\text{SO}_2$  and  $\text{NO}_x$  fumes and they were collected by bubbling samples in an absorbing solution. It was found out that 95 percentile of readings for SPM and  $\text{NO}_x$  were exceeding the prescribed limits, but 95 percentile of the  $\text{SO}_2$  readings were below the reference limit.

Moreover, the seasonal variation was also mentioned in the report, stating winter as the most polluted season, followed by summer and monsoon. The mining activities were declared as solely responsible for the pollution in the area.

**Anastasiadou and Gidarakos** (2006) studied and evaluated the quality of an open air asbestos mine over a very long period, by taking readings of the asbestos fibres concentration in air. The study was done in Asbestos mines of Greece and sampling was performed according to the NIOSH Method 740 for phase contract microscopy (PCM) and also in accordance with the air sampling process notified by EU. Samples were taken at 1.5m above

floor level and the static sampling was done at fixed locations. The recordings were done optically and analysed later with X-ray powder diffraction (XRD).

They also used Scanning electronic microscope (SEM) and the examination of suspected fibres was done with X-ray for their composition. The study revealed that asbestos exposure can be discredited to human activities like excavating, treating asbestos, using it and disposing products into landfills.

**Dahmann et al. (2008)** assessed the exposure of  $\text{NO}_x$  and CO in hard coal mines of Germany. The study involved both measurement and monitoring and it was simultaneously accompanied by an epidemiological study that investigated the possible effects of the gases on the lungs and bronchial areas. As per the standards set by EU, time weighted values of 8 hours were taken and determined. By virtue of the readings a time-dependent cumulative average of NO and  $\text{NO}_2$  was determined for an inception cohort of 2 groups of coal miners. From the study it was revealed that the miners who are part of the blasting crews (not blasting experts) were estimated by experts to experience the majority i.e. two thirds of the nitrogen oxide exposure of blasting specialists. Even the diesel engine drivers endure exposure that is much greater than prescribed values.

**Sharma and Siddiqui (2010)** did a study to assess the air quality in and around Jayant open cast coal mining project situated at Jayant in Sidhi district of MP, India. SO, NO and TSP were measure for 24 hours, once in every 15 days at each sites and concentration was expressed in  $\mu\text{gm}$ . 24 hourly sampling basis was considered to calculate the mean of the pollutants. High Volume sampler (HVS) was used for the sampling of particulate matter and they were collected for 2 years by the help of glass fibre filter paper on fort nightly basis. They also assayed upon the observation on spatial and temporal variations in concentrations of gaseous and particulate pollutants that was previously carried out by Chauhya (2004) during both the year of air observing. From the study it was found out that the highest concentration of pollutants is in the seasons of winter and summer. From the observations, they devised a plan of cleansing transportation roads, wetting the paved and unpaved roads with binding agents and fitting sprinkler system at high polluting coal transport roads within the plant premises and also dust suppression mechanism at coal handling plant.

**Silva et al. (2010)** discovered the importance of monitoring light hydrocarbons, especially from global climate change, economical and safety point of view. Due to absence of correct procedures of gas sampling in Brazilian coal mines, they used standard gas chromatography procedures of gas sampling to determine LHCs (light hydrocarbons) from 2 open cast and 3 underground mines. Sequential sampler was used to collect samples of gas and was kept in polypropylene tedler gas sampling bags. The gas chromatograph equipped with flame ionization detector was used to determine the LHC concentration. The results revealed greater concentrations of LHC in underground mines than surface mines with the level of methane varying widely from 3 ppm to 27% in coal mine atmosphere. The surface mines however, presented concentration ranges of 3ppm to 470ppm. Light hydrocarbons methane is evidently desorbed in greater concentrations from confined coal seams. The study finally revealed that the use of steel canisters is not better than tedler bags and sequential sampler, for the sake of sampling.

**Chen et al. (2010)** studied and handled the use of matter-element method in ambient air quality estimation in the open cast mining coal field projects of Fuxin colliery. In a unique study conducted by Fu et al (2000), it was revealed that air pollution of Fuxin is majorly composed of total suspended material, sulphur dioxide and oxides of nitrogen. To verify the results of this study, 4 different monitoring stations were chosen for sample collection around Fuxin colliery. By using the concept of Fuzzy concept to air quality assessment, on the basis of matter-element theory, they tried to assess the air quality. The idea is good in predicting the influence of dust contaminant on environment based on maximum and minimum exposure limits. They arrived at the conclusion that re-vegetating some sites can help comply with the air quality standards of CAAQS, 1996. The study is instrumental in developing an integrated and developed support system to assess the air quality using a programming language.

**Khan and Bagaria (2011)** tried to find out the effectiveness of meditative measures employed in Dhanappa limestone mines, Nagpur, to suppress air pollutants coming from mining areas. The sites were selected based on the NAAQS standard of anthropogenic

concentration and relevance i.e. sensitive, residential and commercial and industrial area. 104 measurements were taken in a year, with sampling being done twice a week, 24 hourly uniform interval being taken for the study. The annual arithmetic mean of the readings was taken and APM 460 respirable dust sampler was used with cyclone. The intention of using the cyclone was to provide more accuracy for measurement, by separation of PM<sub>10</sub>. West-Geake method and Jacob-Hochheiser method respectively were used to analyse SO<sub>2</sub> and NO<sub>x</sub> on spectrophotometer. Sampling of SO<sub>2</sub> and NO<sub>x</sub> was done using an impinger that was exposed at an impingement rate of 1 LPM for 24 hours to get one sample in day. They inferred that the SO<sub>2</sub> and NO<sub>x</sub> level as per ambient air quality standards reveals low pollution, while RSPM and SPM are moderate. They recommended frequent monitoring and analysis of these parameters, which according to them can help restrict the pollutants to prescribed limits.

**Mandal et al. (2011)** deduced that maximum air pollutants that are suspended in the air and causing health problems are actually generated from the haul and transport roads in the coal mining projects. As per the analysis of Amponsah-Dacosta (using USEPA guidelines), 93.3% of dust in South African coal mines comes from haul roads. The dust doesn't get removed from the haul road entirely because of the partial failure of the available techniques. This study dealt with the qualitative and quantitative aspects of road dusts. Road dust samples were collected from 4 different coalfields of India.

Using an Orion Gas analyser, with a glass electrode, the pH of dust samples was determined; moisture content was calculated using Indian standards; Volatile matter by using a covered crucible and heating the sample in a muffle furnace; ash content by using Indian standards; and fixed carbon by mathematical method. The interesting finding was that coal dust from haul road can be used as a domestic fuel. So, if collected and converted properly into some solid form, it can be effectively used as a domestic fuel.

The following is a brief review of scholarly work of different researchers in the field of Water quality assessment:

**Leitz (1976)** validated the process to clean water up using Electro-dialysis. Positive and negative charged ions are formed whenever a salt dissolves in water. The cations migrate towards negatively charged cathode and anions migrate towards positively charged anode, on application of electrical field across the solution. This concept was used in desalination in water. The apparatus of electro-dialysis consists of a stack of rectangular membranes terminated on each end by an electrode. An ion exchange follows it, where purer water is required. The water produced is used in petroleum refining, petrochemical production, automobile manufacturing and mining (as boiler feed). This process is used underground as an alternative for transportation of fresh water from other sites.

**Robeck et al. (1989)** worked for the reduction and removal of pesticides after DDT started to project detrimental effects on non-target life forms. Latest pesticides like Endrin and Endosulfan are degradable compared to DDT and Dieldrin. The samples were coagulated with alum and different polymers and few effects were obtained. The evacuation of pesticides by routine water medicine procedures was examined, for example alum coagulation, illumination, softening, re-carbonation and chlorination. The evacuation of these pesticides was presumed to be inconsequential and that there was need to improve solid innovation.

**Norris et al. (1990)** researched to find the effective management of monitoring programs of water resources in Colorado and Ohio. Of the 3.08 lakh water samples that they collected from Colorado and 10 lakh from Ohio, they did phase by phase water assessment. In phase 1, they collected, identified and guessed the costs of water quality data collection programs and stated that the data are in accordance with broad scale water quality assessment. In phase 2, the extent of usefulness of data was found out. Of the total samples collected, only 34% from Colorado and 5% from Ohio met the criteria. The areal and temporal scales of assessment had an imbalance, apparently. The information that was provided by the monitoring programs,

especially for the large areas, was inadequate for the conduction of an unbiased assessment of regional surface water and groundwater conditions.

**Singh (1990)** studied the water quality and its condition and its inclination in Jharia coalfields, where businesses remove water apart from the extensive coal mining that occurs in the area. They studied and discovered the detrimental quality of water and its contamination in the entire coal mining zone. They prepared a list of major sources which bring about water pollution and deteriorate the quality of drinking water in the district as coal handling plants and mining acts are being done.

**Jambrik and Bartha (1994)** studied the ancillary impacts of mining in East Borsod Coal basin on the ground water quality. They found out that excess dewatering in almost all the coal basins of Hungary, brings down the hydrostatic pressure of aquifers, reducing the water assets, and bringing imbalance in the water administration of the area and hence polluting it.

**Tiwary and Dhar (1994)** studied the heavy metal contamination of Damodar River, along a stretch of 50kms in the Jharia coalfield area. Metals like Iron, Manganese, Cadmium, Chromium, Nickel and Lead were determined from the sediments of the river bed and the total carryover was carried out in the waterway. It was found out from the study that the contents of Iron and Manganese were irreversibly held in the residue and the impact was in the order of: lead, chromium, nickel and cadmium; in decreasing order.

**Singh (1997)** used a series of experiments to find out the major causes of water pollution in mining are and deduced that the reason behind contamination of water bodies is discharge of mine water effluents, leachates from wash-off dumps, solid waste disposal sites; rocks, toxic wastes, battery disposal, oils, grease, salinity from mine fires, acid mine drainage, sulphide and pyrite ores run off. He mentioned overburden run-off collection and treatment with sediment control, grease and oil separators, collection of seepages, leachates, wash-offs as the primary treatment method. He also suggested the treatment of the collected wastes. Treatment of mine water discharges.



**Smith and Haque (1998)** did extensive study on the drinking water of Taiwan and Argentina and suggested that the ingesting of arsenic present in drinking water resulted in internal cancers, especially bladder and lung cancer. The arsenic levels in water were also investigated upon and cancer mortality was found in a region of Northern Chile. With a 570 µg/litre population weighted average of arsenic level, the standard mortality rate was also found out. The SMR is defined as a ratio or percentage quantifying the increase or decrease in mortality of a study with respect to the general population. If SMR is found to be greater than 1 then the number of deaths is greater than expected. Increased mortality was found for bladder cancer, lung cancer, kidney cancer and skin cancer. It was bladder cancer that was had an elevated level of SMR with 6.0 for men (95% confidence level, CI 4.8-7.4) and 8.2 for women (95% Confidence interval 6.3-10.5). The same was with lung cancer mortality, with SMR for men at 3.8 (95% confidence, CI 3.5-4.1) and SMR for women at 3.1 (95% confidence, CI 2.7-3.7). It was estimated that Arsenic was responsible for 7% death among those aged 30 years and above.

**Ghose and Sen (1999)** did a few examinations in regards to effect on surface water quality because of the dumping of tailings. For the tailings to limit to blend with the ground water, construction of tailing dam for the regulation is an unquestionable requirement. Even the construction isn't a guarantee to the environmental immunity to pollution. Humongous amount of water is required for the beneficiation of iron metal, so after the beneficiation, water with tailings are dumped into the lake and water is generally recycled after treatment with a thickener. This leads to efficient use of water. For most part of water pollution, it is because of the contamination by suspended solids, especially if the handling of tailings is not fitting. Genuine concern in such manner is the direct release of tailings into water bodies. To evaluate the effect on surface water quality, they gathered specimens from the stream, nallah close to the iron metal mine in Sundergarh region. A few parameters like temperature, pH and dissolved oxygen are measured at site while others (chemical O<sub>2</sub>, hardness, general metals) are measured later on. They likewise discovered other trace metals defouling the surface water, regardless of the possibility that they were present within permissible standards.

**Hopke et.al. (2000)** studied the health hazards because of the presence of radon in drinking water. By and large it came to blend with drinking water from the indoor air; however its conc. is less. Of all the isotopes, Radon poses the biggest threat to human body. The danger of radon discharged from water, even at ordinary groundwater levels, was evaluated to be bigger than the dangers of the other drinking water contaminants that have been subjected to regulation. Radon in water additionally displays a direct ingestion hazard. The danger of growth emerged from the ingestion of radon broke up in water. The R-molecule created different locales of DNA damage bringing about destruction and adjustments of chromosomal sites and prompting the hereditary hazards embroiled in tumour movement. When radon has entered the blood, through either the stomach or the small intestine, it is dispersed among the organs and it was extremely perilous then.

**Baba et.al. (2003)** considered the impact of Yatagan Thermal Power Plant (Mugla, Turkey) on the standards of surface and ground waters. Their study publicized that the centralizations of  $\text{Ca}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Sb}^{2+}$  and  $\text{SO}_4^{2-}$  in a few examples surpass the Drinking Water, U.S. EPA and WHO limits. Isotope investigations were find the starting points of waters, which demonstrated that pollution is occurring in the region of the waste dumping site of power plant.

**Akcil and Koldas(2006)** researched that the significant extent of water is contaminated because of Acid Mine Drainage. They found that Acid Mine Drainage (AMD) is created when sulphide-bearing material is presented to oxygen and water. Iron sulphides alongside other metal sulphide minerals might likewise deliver AMD. It has low pH, high particular conductivity, high levels of iron, aluminium, and manganese, and low levels of poisonous substantial metals. They found that variables like pH, temperature, Oxygen content of the gas stage, Oxygen level in the water phase, degree of immersion with water, Chemical action of  $\text{Fe}^{3+}$ , Surface range of uncovered metal sulphide, Chemical activation energy needed to start corrosive action. Bacterial acts also influence the rate of acid production. They revealed that the AMD can be controlled by the following ways:

- Changing the flow of surface water in the direction where pollution is more.
- The ground water and pollutants shouldn't be allowed to mingle.

- Seepage of water should be prevented using proper measures.
- Proper disposal of acidic wastes that have the potential to pollute water.

**Qian et.al. (2007)** made surface water quality assessment utilizing multivariate strategies and another water quality index in the Indian River Lagoon, Florida. They installed 6 stations at 6 areas and unceasingly checked them. They utilized clustering technique to cluster the 6 checking stations in 3 gatherings with stations on the same or distinctively comparative stations in same group. At that point they did the assessment of the gatherings and figured out the inferences of water quality tests.

**Kar et.al. (2008)** evaluated the excessive water contamination in surface water. They accumulated what signified to 96 surface water samples from river Ganga in West Bengal all through 2004-05 and did extensive study on the pH, Electrical Conductivity (EC), Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Cadmium (Cd), Chromium (Cr), Lead (Pb) and Nickel (Ni). They found that among the considerable overwhelming metals themselves, a huge negative relationship was seen in the middle of Fe and Cr, while Ni showed a critical positive relationship with Mn and Zn.

**Bishnoi and Malik (2008)** did extensive study on the precise physico-chemical analysis of the groundwater at 41 distinct areas in Panipat city (Haryana), India to assess its suitability for household purposes. Their study uncovered significant varieties in the water tests concerning synthetic arrangement and they found that all examples have high convergance of broken down salts and all the specimens were hard.

**Ramakrishnaih and Ranganna (2009)** surveyed water quality index for ground water of tumkur taluk, Karnataka. They gathered groundwater tests and did a physiochemical examination on the specimens. For computing the WQI, they considered the 12 parameters, viz. pH, complete hardness, calcium, magnesium, bicarbonate, chloride, nitrate, sulphate, TDS, iron, manganese and fluorides. The WQI for these specimens ran from 89.21 to 660.56. This examination uncovered that the groundwater of the territory required some level of

treatment before utilization, and it additionally needs to be shielded from the dangers of drinking.

**Gendren et.al. (2009)** observed that surrounding convergences of metals in surface waters have become an essential thought when building water quality criteria and evaluating risk. Their study included the estimation of measures of copper that may be discharged into fresh and estuarine waters considering permissible concentrations, toxicity limits, and bioavailability. Aggregate dissemination elements of ambient copper fixations were thought about statistically for individual sites inside 14 surface water tests of North America and Europe to recognize contrasts among mean dispersion variables.

**Tiri and Boudoukha (2010)** considered the nature of water surface of Koudiat Medouar dam. They examined the water quality and the outcomes uncovered that surface water quality was mostly determined by topography, agrarian uses and household releases. They additionally found that water is heavily affected by geology, and by hints of metals (iron, lead), furthermore affected by large amounts of nitrate, ammonium and sodium because of urban contamination.

**Liu et.al. (2011)** gave a methodology to enhance the management of water quality in mining. The potential environmental impacts of freshwater withdrawal and mine water release are a portion of the fundamental drivers for the mining business to enhance water administration. The utilization of numerous water supplies and bringing water reuse into the mine site water framework ought to be utilized by the mining industries. Nonetheless, a hindrance to usage of such good water administration practices is accompanying water quality variety and the subsequent effects on the effectiveness of mineral beneficiation, and an extensive natural impact of discharges. In this paper they proposed a methodology that could aid mines to oversee water quality issues in an orderly way at the system level. Water is all the while moved to processing plant, mine workings, tailings from the blender (including new water). The worked water is cleaned and again sent to the blender while the water recovered from the processing plants in the mid is moved specifically to the blender with no cleansing. This methodology can quantitatively figure the danger related with water quality and assess the

efficiency of administration techniques in moderating the danger by measuring ramifications for creation and subsequently financial feasibility.

**Jordaan (2012)** had studied the water quality of processing of oil sands in Alberta. Development of oil sands created not just in the release of greenhouse gas surges, additionally influences land and water resources. The surface water is contaminated by oil sands operations, is a prime instance of this. The surface water requirements for oil sands are significantly more different than that of the cultivation reason. The northern stream of Alberta, where oil sands stores are systematic and arranged, have a relative abundance of water instead of the south where water is starting now uncommon and there is progress in cultivation. With the development in oil sands era, water use also climbs. Water availability in the Athabasca River is supposed to decline in light of environmental changes later on while oil sands development keeps increasing. Withdrawals all through this time may impact a greater part of aquatic life and decrease the measure of broken oxygen available to fish in the winter. Suitable levels of broken oxygen may concede brooding, change the mass of post hatched fish and change creating periods for particular sorts of fish. Raised levels of Polycyclic Aromatic Compounds (PACs) had been found in the water tests. Regardless of the way that the PACs were not found to land at near to gatherings in this study, they were found to be at levels sufficiently high that are likely toxic to fish creating lives. A second study showed that the levels of seven toxins (cadmium, copper, lead, mercury, nickel, silver, and zinc) were found to have surpassed Canada or Alberta's standards for the certification of amphibian life.

### **3**                    *Effect of Air pollutants on different organisms and systems*

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PM<sub>2.5</sub> and PM<sub>10</sub> levels are as of now the acknowledged criteria of National Ambient Air Quality Standard (NAAQS) for evaluating the air quality.

Taking after are the two reasons examined:

1. Long retention of fine particulate matter (diameter < 10 $\mu$ ) in ambient air-

Tiny particles have a moderately high surface zone in every unit mass. A centimetre cube of quartz molecule if broken into particles of 1 $\mu$ m<sup>3</sup>, there will be 10<sup>12</sup> particles with surface region of 6m<sup>2</sup> as compared to just 6cm<sup>2</sup> zones of original quartz cube. Their terminal speeds being unnoticeable and of the order of cm/hour or even mm/hour, they can stay in air borne state for quite a while.

2. Relative sparse absorption of fine particulate matter (diameter < 10 $\mu$ ) in upper respiratory track-

All dust below 10 $\mu$ m are considered as hazardous because of the fact that they don't get absorbed in the upper respiratory track, such as trachea, bronchi and reach the alveoli producing toxic effect like dyspnoea, thickening of alveolar walls, etc.

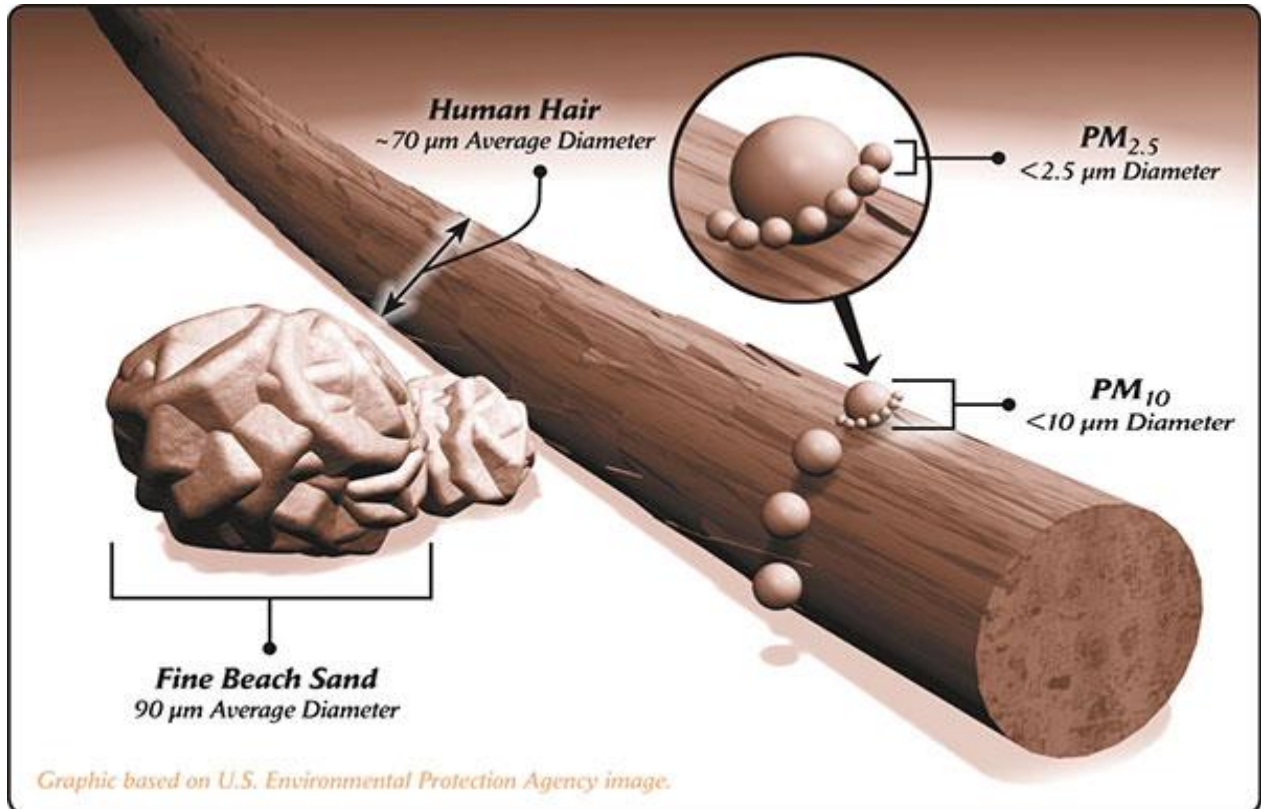


Fig 3.1. Size of particulate matter

### 3.1. HARMFUL EFFECTS OF PARTICULATE MATTER ON HUMAN HEALTH:

- **Respiratory System:**

Various studies reveal that a wide range of air contamination, at high concentration, can influence the respiratory airways. However, the same effects are observed on exposure to pollutants of lower concentration for a very long period. For example, nose and throat disturbance, trailed by bronchial-constriction and dyspnoea, particularly in asthmatic people, are normally experienced after introduction to higher levels of sulphur dioxide, nitrous oxides, and certain substantial metals for example, arsenic, nickel or vanadium. Moreover, particulate matter that enters the alveolar epithelium begin lung irritation. Patients affected with lung diseases, have their condition deteriorated by inflammation that is initiated by pollutants. Apart from these, gases like nitrous oxide expand the defencelessness to respiratory contaminations. Also, long term exposure to ozone and certain overwhelming metals lessens lung capacity, while the later are likewise in charge of asthma, emphysema, and even lung growth. Emphysema-like injuries have additionally been seen in mice presented to nitrogen dioxide.

On inhalation, we take in air along with many other contaminants and particles. This breath of air, along with the particles, travel into the respiratory system, and along the way the particles can stick to the sides of the airway or travel much deeper into the lungs. The respiratory system is equipped with defence mechanism like mucous and cilia to stop particles of bigger size getting into the lungs. But  $PM_{2.5}$  gets down to the alveolar level and intermix during the gas exchange between blood and air. These pollutants pose significant risk to the alveoli and there are no efficient means or mechanisms to remove them. If the particles happen to be soluble in water, then they mix with the blood stream in a matter of minutes. However, if the pollutants are not soluble in water, they continue to be in lungs and in a matter of months and years, they lead of lesion and inflammations, which can be carcinogenic in nature. The USEPA reported that, “studies recommended little particles can leave the lung and go through the blood to different organs, including the heart”.

- **Circulatory and Cardiovascular system:**

Carbon monoxide ties to haemoglobin altering its conformity and diminishes its ability to carry and exchange oxygen. This decreased oxygen accessibility affects the



capacity of diverse organs (and particularly high oxygen devouring organs, for example, the mind and the heart), bringing about weakened fixation, moderate reflexes, and disarray. Aside from lung irritation, systemic inflammation is caused by particulate matter, influencing similar blood coagulation. Air contamination that affects lungs and changes in blood thickening can block (cardiovascular) veins, prompting angina or even to myocardial infraction. Side effects, for example, tachycardia, expanded pulse and pallor because of an inhibitory impact on haematopoiesis have been seen as an outcome of substantial metal contamination (particularly mercury, nickel and arsenic). At long last, epidemiologic studies have connected dioxin presentation to expanded mortality, brought on by ischemic coronary illness.

- **Nervous system:**

It has been exhibited that different parts of air contamination, for example, nanosized particles, can undoubtedly translocate to the CNS where they can initiate characteristic resistant reactions. Besides, systemic aggravation emerging from the pneumonic or cardiovascular framework can influence CNS health. Notwithstanding extreme studies on the physical impacts of surrounding air contamination, the fundamental sub-atomic systems of powerlessness and illness remain to a great extent subtle. Be that as it may, rising confirmation recommends that air contamination incited neuroinflammation, oxidative anxiety, microglial initiation, cerebrovascular brokenness, and adjustments in the blood-cerebrum boundary add to CNS pathology. A superior comprehension of the go between and components will empower the improvement of new procedures to secure people at danger and to decrease adverse impacts of air contamination on the sensory system and psychological well-being.

- **Digestive System:**

Dioxins actuate liver cell damage, as revealed by an increment in levels of specific catalysts in the blood, and additionally gastrointestinal and liver malignancy.

- **Urinary System:**

Heavy metals can lead to kidney failure, for example, a beginning tubular brokenness confirm by an expanded discharge of low molecular weight proteins, which advances to diminished glomerular filtration rate (GFR). Likewise they build the danger of stone development or nephrocalcinosis and renal tumor.

### **3.2. EFFECT OF MINE GASES:**

- **Nitrous Fumes:**

The higher oxides of nitrogen (NO, NO<sub>2</sub>, and higher valence) are exceedingly responsive gases that are part of the mining process automobile exhaust and are primary constituents of photochemical air contamination. Their chemical properties bring about direct oxidation, free radical development, nitrosation, nitrite particle discharge, and paramagnetic communications with heme. NO is produced from the oxidation of air N<sub>2</sub> in the inward burning motor and is changed over to NO<sub>2</sub>, the compound of more prominent danger. Inward breath of NO<sub>2</sub> at high levels may bring about a triphasic arrangement of intense bronchospasm, postponed pneumonic edema, and late bronchiolitis obliterans. Low levels seem to impel aspiratory fibrosis with chronic symptoms and to restrain pneumonic safeguard instruments, especially macrophage capacity and ciliary motility. Fauna and human populace studies propose that the most serious danger from low quantity long term introduction is decreased host imperviousness to viral and bacterial respiratory tract diseases.

- **Sulphur Dioxide:**

Moderate actions that trigger mouth breathing, for example, a lively walk, are required for sulphur dioxide to bring about detrimental effects to the health. Individuals with asthma who are physically dynamic outside are most susceptible to the detrimental impacts of sulphur dioxide. The fundamental impact, even with extremely concise introduction (minutes), is narrowing of the respiratory passages (called bronchoconstriction). This is often associated with wheezing, midsection snugness, and shortness of breath, which may need the utilization of medicines that opens the respiratory passages.

Indications increment as sulphur dioxide levels or breathing rate increments. At the point when introduction to sulphur dioxide stops, lung work normally comes back to typical inside 60 minutes, even without prescription. At abnormal states, sulphur dioxide may bring about wheezing, midsection snugness, and shortness of breath even in fit individuals who don't have asthma. Long haul introduction to sulphur dioxide may bring about respiratory side effects and sickness, and disturb asthma. Individuals with asthma are the most vulnerable to sulphur dioxide. Notwithstanding, individuals with other perpetual lung infections or cardiovascular ailment, and in addition youngsters and more seasoned grown-ups, might likewise be vulnerable to these impacts.

- **Hydrogen Sulphide:**

Commonly known as stink damp, it smells like rotten egg, and has a taste that resembles sweetness. More poisonous than CO, as per regulations of ACGIH, it can't cross 0.001% in any workplace. At a concentration level of 0.02 to 0.03% and an exposure time of 1 hour, can lead to marked symptoms, while with a concentration of nearly 0.07% and an exposure time of 30 to 60 minutes, it can lead to serious poisoning. Excessive exposure can lead to respiratory paralysis and asphyxia leading to death.

- **Carbon Monoxide:**

Produced from the blasting fumes, exhaust of automobiles and mine fires, CO is a colourless, odourless and poisonous gas that is slightly heavier than air. Since the haemoglobin has a high affinity towards carbon monoxide, approximately 250 to 300 times more than it has for oxygen, so it leads to breathlessness and results in death. On long exposure the cells suffer damage and the patient experiences headache, nausea, mental disorder, memory loss, paralysis and unconsciousness. With levels around 0.01% for a long time, slight headache occurs with chronic poisoning and exertion. With concentration increasing till 0.4%, it can prove to be fatal in a few minutes.

## **4**      *Effects of polluted water on living organisms and systems*

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Water pollution leads to a lot of diseases, which can be categorised into 3 main groups:

#### 4.1. DISEASES CAUSED DUE TO POLLUTED WATER:

- **Typhoid:**

Typhoid fever is also known simply as typhoid. It is a common bacterial disease spread worldwide and transmitted by food or water which is contaminated with faecal matter of an infected person. These contain the bacterium *Salmonella Typhi*. Also known as abdominal typhus, remittent fever, nervous fever, slow fever, gastric fever infantile and pathogenic fever.

- **Amoebiasis:**

It is a gastrointestinal infection which may or may not show symptoms and can also remain latent inside an infected person for many years. Amoebiasis causes 70,000 deaths a year throughout the world. If symptomatic it shows symptoms ranging from minor diarrhoea to dysentery with mucus and blood in stool. Otherwise the infected individual can still be a carrier.

- **Giardiasis:**

Giardiasis (or beaver fever) disease caused by the parasite flagellate protozoan *Giardia lamblia*. It is the common reason behind gastroenteritis, infecting nearly 200 million people globally. Some of the symptoms include appetite loss, haematuria (blood present in urine), diarrhoea, stomach cramps, bloating, excessive gas, sometimes projectile vomiting. Symptoms usually show up one or two weeks after the infection.

- **Ascariasis:**

Ascariasis is caused by the parasite which is a roundworm called *Ascaris lumbricoides*. Most of the infections have no symptoms (if the worm count is small). Symptoms generally increase with increase in the number of worms and can also include shortness of breath and a bit of fever during the initial phase of the disease which is followed by some symptoms of abdominal pain, abdominal swelling, and also diarrhoea.

- **Hookworm:**

Hookworm is a parasitic nematode living in the host's small intestine. The host may be human or any mammal. Hookworms affect around 576 million people worldwide.

They are the major cause of mother and child sickness in the third world countries. Children born from infected mothers can be affected with cognitive, intellectual and overall growth and intrauterine growth retardation, premature birth with low weight at birth. While in the developed countries this disease is not much of a problem, although it can cause anaemia if the infection is severe.

#### **4.2.EFFECT ON TREES & PLANTS:**

- (a) Disrupts photosynthesis causing imbalance in ecosystem.
- (b) Plants absorbing these can pass it down the food chain (bio magnification).
- (c) Too saline water can kill the plants.
- (d) Mud from construction sites can kill plants.
- (e) Herbicides in water can kill plants too.



## **5.1. COLLECTION AND PRESERVATION OF SAMPLES:**

Collection of representative sample is the main objective of sampling. Samples should be collected in such a way that the ratio, proportions or concentration of all the related components will be same in the sample as the main source. Handling of samples should ensure that the neither the quality of the water samples nor the quantity of components in the water undergo any kind of change. Only that amount of water should be collected which is enough to carry out all the tests and is optimal to carry anywhere.

With increasing need of accurate representation and authenticity of data presented in the reports, more and more attention should be dedicated on the genuine collection of samples, their tracking and storage procedures. Some consultation is obliged which is fundamental to ensure selective sampling and orderly frameworks that give a sound and honest ground to the premise for watching the questions that induce the investigation and that will meet authoritative and/or assignment specific necessities.

## **5.2.REQUIREMENTS OF SAMPLING:**

- Collect only the samples that meet the necessities of the inspecting program and handle it so it doesn't disintegrate or get to be fouled before it is investigated.
- Ensure that all sampling hardware and instruments are clean and quality-guaranteed before utilization. Only those test compartments that are clean and free of contaminants should be utilized.
- Sample compartments are filled without prerinsing with the collected samples; prerinsing results in loss of any preadded preserverant and at times can lead to skewed results owing to the components that adhere to the sides of the sample vessel. On the basis of the parameters that are to be estimated, the vessel is filled full (most organic compound determinations) or some space is left for air circulation, blending, and so on (microbiological and inorganic investigations).



- Special precautionary measures are essential for the samples containing natural organic components and low level of trace metals. There are many constituents that are present at low levels (micro scale grams or nano-grams every litre), they may be absolutely or somewhat lost or effectively lost when legitimate inspecting and safeguarding systems are not taken.
- Composite specimens can be acquired by gathering over a span of time, or at various places over a period of time, profundity, or at a wide range of sampling points of interest. The subtle elements of gathering change with nearby conditions, so particular references are not generally relevant.
- In case of metals it is important to gather both filtered and unfiltered samples to differentiate the amount of dissolved metals present in both. Filtering also prevents machines likes AAS from measurement failure and malfunction. Care must be taken because a few metals might partially be absorbed in the filters. Prior to the experiments, determine the acid required to bring the pH to under 2 on any sample. The acid used has to be ultra-pure acid to prevent any kind of contamination of sample. Before measurement, filtered samples are to be collected, filtered on site or at the point when they are being infused with acid.

### **5.3.FOLLOWING RECORDS OF SAMPLES HAVE TO BE MAINTAINED:**

- General Information
  - Sample number
  - Location
  - Sample Collector
  - Date and time
  - Sampling type
- Specific Information
  - Temperature of water
  - Weather
  - Blow direction of stream
  - Water level
  - Any other relevant information
- Any water bodies like rivers, lakes, reservoirs or streams are prone to seasonal variations such as seasonal changes, diurnal variants, monsoon, wind etc. The

place of sampling, the depth, the number of samples collected should be based on local conditions and the reason of quality check. In places of extreme disturbance, sampling should be avoided as it can lead to loss of many components and of possible presence of poisonous vapours that are denser than air.

#### 5.4.TYPES OF SAMPLES:

- **Grab Samples:** A distinct sample gathered at a specific time and spot that is representative of the configuration of the water, air, or soil just around then and spot. Grab samples are uniquely gathered at a particular spot of a site over a brief span of time (commonly seconds or minutes). Hence, they are generally a “capture” in both space and time of an examining zone. Discretely taken grab samples at chosen areas, profundity, and time are properly noted. Depth incorporated grab samples are gathered over a previously determined space of the whole depth of a water section, at a chosen area and time in a given waterway.

At the point when a source is known to shift with time, samples are gathered at suitable interim and broken down independently can record the degree, recurrence, and term of these varieties.

- **Composite Samples:** A mixture of various single or "grab" tests, expected to deliver an ordinary or normal example may be comprised of equivalent volumes of individual specimens, or of single examples proportioned to varieties in stream or use. Composite specimens ought to give a more illustrative examining of heterogeneous lattices in which the amassing of the analytes of interest may change over brief span of time and/or space. Composite samples can be acquired by joining segments of various grab tests or by utilizing exceptionally outlined programmed sampling gadgets.

Moreover, composite samples consolidate lessened costs of exploring incalculable, more illustrative specimens of heterogeneous systems, and greater sample sizes when measures of test examples are obliged. Downsides of composite examples include adversity of analyte associations in unmistakable specimens, potential debilitating of analytes underneath recognizable proof levels, extended potential deliberate impedances, and extended likelihood of analyte participations. Additionally, usage of composite examples may diminish the

measure of cases separated underneath the obliged quantifiable necessity for determined data quality objectives or job specific targets.

#### 5.5.SAMPLING METHODS:

- **Manual Sampling:** Manual sampling includes negligible use of apparatus yet may be unduly expensive and lengthy for normal or vast scale sampling projects. It obliges expert field specialists and is frequently essential for administrative and investigative examinations for which proper evaluation of field conditions and complex sample accumulation methods are the key. Some samples should be collected manually, like water containing oil and grease.
- **Automatic Sampling:** Automatic samplers can dispense with human mistakes in manual sampling, can decrease work expenses, may give the measures to more continuous sampling and are being utilized ever more. It's important to ensure that the automatic sampler doesn't contaminate the sample. Example, plastic parts may not be compatible with certain organic aggravates that are dissolvable in the plastic parts or that can be debased (e.g., from phthalate esters) by coming in contact with the containers. The manufacturer of an automatic sampler is to be contacted, if the sample constituents are generally known and be asked regarding the potential incompatibility of plastic components.

#### 5.6.SAMPLE COLLECTION:

- The samples were collected from the following sites:

Sl. No	Mines Name	Ore Type	Location of sampling
S-1A	Samaleshwari OCP, MCL	Coal	Drinking Water for the workers
S-1B	Samaleshwari OCP, MCL	Coal	Sump Water
S-2	Kiriburu Iron Ore Mines, SAIL	Iron Ore	Drinking Water near the mines
S-3A	OCL, Lanjiberna	Limestone and Dolomite	Quarry 1&2 discharge water
S-3B	OCL, Lanjiberna	Limestone and Dolomite	Quarry 3 discharge water
S-4	Tata Steel, Sukinda Mines	Chromite	Quarry discharge water

Table 5.1. Sites of sample collection



The intention of choosing 4 different mines of 4 different ore types is to find out the effect of an ore type on the amount of dust particles that are suspended in the air. In an open cast mines, the dust particles remain suspended in air for a very long time. Since drilling, blasting, loading and haulage are integral to all the mines, it is a point of interest to know the amount of dust that remains suspended in air. Especially PM<sub>2.5</sub> and PM<sub>10</sub>. An analysis of these parameters will help us understand the various mitigation measures that are required to control the amount of dust that is suspended in the atmosphere. A proper analysis of the size of the particles related with the ore type can help us plan better in future and design the preventive measures in a much better way. The amount of dust suspended in a coal, iron ore, limestone and chromite mines, when analysed can give us proper insight into the size of the particles that are more inclusive to the type of ore.

### 6.1. METHODOLOGY:

- Each and every mines has to maintain the record for the environmental standards, on a frequent basis. We collected the data maintained by the mines, which were either measured by CIMFR, or outsourced to companies like Cleenviron Private Limited or even self-administered.
- The results of the measurement have been taken and analysed and the dependence of ore type on the dust suspended in air has been studied.

### 6.2.STANDARDS:

Table 6.1. Ambient Air Quality Standards (National):

Pollutants	Time weighted average	Concentration in ambient air		
		Sensitive of Areas	Industrial Areas	Residential, Rural & Other areas
Sulphur Dioxide (SO <sub>2</sub> )	Annual Average	15 µg/m <sup>3</sup>	80 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>
	24 hours	30 µg/m <sup>3</sup>	120 µg/m <sup>3</sup>	80 µg/m <sup>3</sup>
Oxide of Nitrogen as NO <sub>x</sub>	Annual Average	15 µg/m <sup>3</sup>	80 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>
	24 hours	30 µg/m <sup>3</sup>	120 µg/m <sup>3</sup>	80 µg/m <sup>3</sup>
Respirable Particulate matter (RPM), (PM <sub>10</sub> )	Annual Average	50 µg/m <sup>3</sup>	120 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>
	24 hours	75 µg/m <sup>3</sup>	150 µg/m <sup>3</sup>	100 µg/m <sup>3</sup>

### **6.3.WATER QUALITY ANALYSIS:**

Water quality of any body is the measure of the physical, chemical, biological and aesthetic parameters associated with the water body. It is a measure of the quality of water that is provided to the aquatic life which is dependent on it for survival and also human use. There are 2 aspects of any water source or body that can't be ignored- i. quantity and ii. quality. Since quality is a relative aspect, so a scale has been set up to assess the standard of a water body, which is the compliance limit set up by regulatory bodies. A good source of water would be the one that can strictly adhere to the limits set and supports a rich class of aquatic life and/or might be fit for human usage. A considerable lot of our own uses rely on upon water quality that is suitable for watering system, watering stock, drinking, angling and diversion, and to meet social and profound needs. Indeed, even water quality is essential for good waterway wellbeing. Water quality manages natural courses of action that bolster local fish populaces, vegetation, wetlands and birdlife.

### **6.4.METHODOLOGY:**

- The water samples were collected from 4 different mines of 4 different ore types. Emphasis was given on the collection of water from the sump of the mines or the discharge point. In places where there existed no sump (KIOM, SAIL), the water was collected from the nearest drinking source point of the mines. It was taken in order to study the effect of ore type and mining on the ground water.
- The samples were collected from the sump of the mines, since all the water that runs off the surface in mines and the waste water, is deposited in the sump. It gives a good indication of the level of contamination of the water due to contact with the ore bodies and is an indicator of the level of pollution. Moreover, it is the sump water whose contact with ground water of fresh water can cause pollution.
- 2 litres of water samples were collected from each source point and were stored in sample bottles.
- The water collected for the purpose of metal measurement were ingested with acid (ultrapure with  $\text{pH} < 2$ ) at the site of sampling.
- The water collected was run through a series of tests, as a result of which the physical parameters, chemical parameters and metal presence were measured and analysed.

- The parameters were analysed using a multi-parameter water quality meter, Atomic Absorption Spectroscopy and Flame photometry.

#### **6.5. PHYSICAL PARAMETERS:**

- Colour
- Turbidity
- Conductivity
- Solids
- Odour
- Temperature

**Turbidity:** It is an indication of the cloudiness of a water source or solution. It indicates the amount of dispersed and suspended solids in a solution, namely silt, algae, clay and other organic matters. The unit of turbidity is Nephelometric Turbidity Unit.

**Conductivity:** Conductivity of any solution is defined as its ability to conduct heat, electricity or sound through it. The unit of conductivity is **mS/cm or mS/m**.

Significance of conductivity:

- Needed to assess the level of pollution
- In coastal belts, it can be used to detect the level of intrusion of sea water into fresh water.
- It is an indirect method of finding inorganic dissolved salts.

**Solids:** It is the amount of matter (both filterable and non-filterable) that stays as residue on evaporation and subsequent drying at a pre-defined temperature. The solutions or water bodies having high amount of dissolved solids are unfit for consumption. Many industrial applications are also affected due to the high content of dissolved solids. Total solids also gives rise to increase in conductivity, due to presence of ions. Analysis and understanding of solids is critical to understand the type of water body and measures needed to treat the water.

**Total Dissolved Solids:** It is the total amount of inorganic and organic matter present in a solution, in a suspended form. It can alternatively defined as the filterable residue that can pass through a glass filter disk and stay intact after evaporation and heating at 180 deg C.

Significance:

- They affect the aesthetic of a water body, affecting the colour, taste and odour.
- Some solids also result in reduced level of dissolved oxygen in water.
- Some can be carcinogenic.
- Industrial use is deeply affected and the product quality is subdued due to the presence of dissolved solids.

#### **6.6.CHEMICAL PARAMETERS:**

- pH
- Hardness
- Nitrate
- DO
- BOD
- ORP

**pH:** It is also called potenz de hydrogen. It is the measure of acidity or alkalinity of a solution.

If  $\text{pH} < 7$ , the solution is acidic

If  $\text{pH} > 7$ , then it is basic and

if  $\text{pH} = 7$ , the solution is neutral.

**Significance:** pH is one of the most important indicators of the life-sustaining ability of a water body. It gives us insight about the acidity or basicity and what type of preventive and treatment measures are required to control it.

**Hardness:** It is the property of water which indicates the mineral substance in water. Hard water contains bicarbonate, chlorides and sulphates of calcium and magnesium.

**Significance:**

- Soft waters are destructive and break down the metals.
- Cardio-Vascular illnesses are accounted for in soft-water territories.
- Hard water is valuable in the development of infants and children.
- Excessive cleanser is used in presence of hard-water.



**Nitrate:** It is the greatest/maximum oxidised form of nitrogen compounds that can be found in natural waters. Chemical fertilizers, decomposed vegetables and animal faeces, domestic discharges, sewage disposal to land, industrial discharge, leachates from refuse dumps and atmospheric washout are the general sources of nitrate. Although, it is found and occurs in almost all water bodies, but its content goes high when near a coal mines, due to the organic presence.

**Dissolved Oxygen:** All living creatures need oxygen in some form to continue the metabolism that produces energy for growth and recreation. DO is also required for precipitation and in the dissolution of inorganic content in water.

Significance:

- For keeping a check on stream's pollution and to assess the quality of raw water.
- DO helps in estimation of the role of aerobic and anaerobic organisms in biological changes, in the wastewaters.
- BOD tests are based on the DO tests.
- All aerobic biological wastewater treatment processes are based on the DO tests and their results.
- Control of amount of oxygen in boiler feeds is done using DO tests.
- There should be DO in drinking water for good taste

**Bio-Chemical Oxygen Demand (BOD):** It is the amount of oxygen required for by the aerobic biological organisms in water for breaking of organic content present in the water sources at a particular temperature and over a certain period of time.

Significance:

- It is an indicator of bio-degradability of any sample and strength of wastes present in the sample.
- It is used to analyse the level of pollution of any water source, especially when the contamination is due to domestic and industrial effluents.
- Water bodies having BOD greater than 5mg/L are impure.
- Efficiency of a plant can be assessed by analysing the BOD and effluent BOD.

**Oxygen Reduction Potential (ORP):** It is the ability to break down contaminants and is also a measure of the cleanliness of water. It varies between -2000 to +2000mV.

**Significance:**

<b>ORP Level (mV)</b>	<b>Application</b>
0-150	No use
150-250	Aquaculture
250-350	Cooling Towers
400-475	Swimming pools
450-600	Hot Tubs
600	Water Disinfection
800	Water Sterilization

**6.7.Metal Contamination:****Lead:**

- Decrease in physical or mental development in infants and children
- Kidney problems; high blood pressure for adults
- Hearing loss
- Hypertension
- Death at higher concentration

**Mercury:**

- Kidney failure
- Loss of vision and hearing ability
- Decrease in intellectual level
- Nervous system disorder

**Cadmium:**

- Kidney damage

**Chromium:**

- Allergic dermatitis
- Skin irritation
- Nasal ulcers
- Lung tumours
- Damage to nervous system and circulatory system at higher concentration level

**Copper:**

- Short term exposure: Gastrointestinal distress
- Long term exposure: Liver or Kidney damage.

- Anaemia
- Disturbances in digestive system
- Blue-green staining on plumbing fixtures
- Bitter metallic taste

**Zinc:**

- Metallic taste

**Nitrate:**

- Blue baby disease in infants

**Arsenic:**

- Weight loss
- Depression
- Lack of energy
- Affect the skin and nervous system in higher concentration
- Skin damage or problems with circulatory systems,
- In higher concentration, increased risk of getting cancer

**Iron:**

- Bitter taste
- Alter the taste of water and beverages

**6.8.STANDARDS:**

Table 6.2. Indian Standard Specifications for Drinking Water IS 10500

S.NO.	Parameter	Requirement desirable Limit
1	pH	6.5-8.5
2	Turbidity	10
3	Total Hardness	300
4	Copper (in mg/l)	0.05
5	Iron (in mg/l)	0.3
6	Nitrates (in mg/l)	45
7	Mercury (in mg/l)	0.001
8	Cadmium (in mg/l)	0.01
9	Arsenic (in mg/l)	0.05
10	Lead (in mg/l)	0.1
11	Zinc (in mg/l)	5.0
12	Chromium (in mg/l)	0.05

# 7 *Equipments & Procedure*

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## 7.1.HORIBA WATER QUALITY MONITOR(U-52G)



Fig7.1. Horiba Water Quality Monitor

Horiba water quality monitor is a multi-parameter water quality checker which enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. With an intricate design, it is a user friendly equipment, used to measure physical and chemical parameters of water sources on site and even in lab. The equipment can be used to measure water quality of rivers, lakes, ground water, drainage water. It can be used to measure up to 11 parameters namely:

- pH
- ORP
- DO
- Conductivity
- Salinity

- TDS
- Seawater
- Specific Gravity
- Temperature
- Turbidity
- Water depth

Principle:

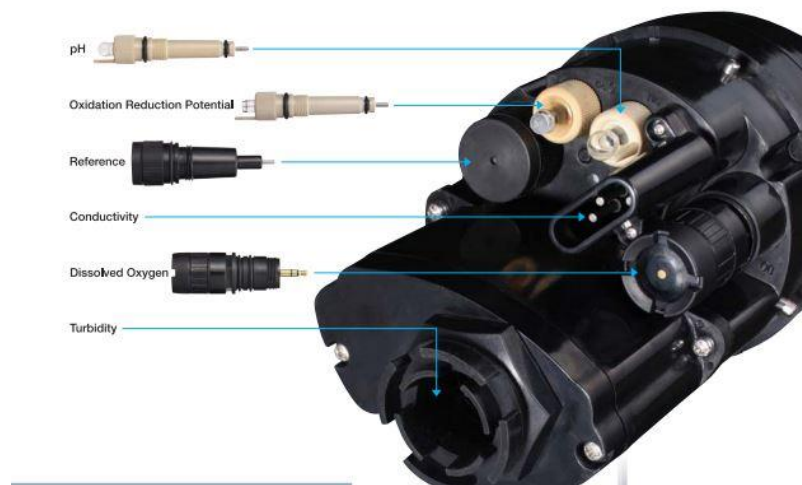


Fig.7.2. Location of sensors in multi-parameter equipment

- There are multiple sensors for the measurement of the 11 parameters, in an instantaneous and simultaneous way.
- The main sensors are of LED type and high precision turbidity sensors of resolution 0.1NTU.
- DO sensor has 3 electrode design to measure in a fast manner and there's also polarographic sensor for ease of maintenance.
- pH and ORP electrodes have low replacements costs and can be changed without much effort.

## 7.2.FLAME PHOTOMETER:



Fig7.3. Flame photometry instrument

It is an instrument which is used to detect the presence of elements like lithium, calcium, sodium and potassium. The instrument is designed and based on the latest microcontroller technology and advanced engineering techniques for the better analysis of these parameters.

Different features:

1. Microprocessor with printer interface.
2. Automatic gas cut-off system
3. Auto flame failure detection unit
4. Four parameters measurement in a single aspiration
5. Data storage facility
6. Setup data storage facility
7. Curve calibration programmability
8. Multiple calibration of curve
9. Direct results in ppm and meq
10. Online help key

**PRINCIPLE:**

The standard solution is aspirated through the Atomiser unit. The standard solution, air and fuel are mixed inside the mixing chamber to convert into fine particles of mist; then it is sprayed into the flame. The concentration of the elements reflected through the change in colour of the flame. The radiation flame passes through the sensing unit and the narrow band of interference filter which allows the specific characterized radiation to the photo detector. It analyses the radiation and display the output data on the LCD screen.

Table 7.1. Specifications of Flame Photometry Instrument

Mode	General
Range	Na: 0-100ppm K : 0-100ppm Ca: 0-100ppm Li : 0-100ppm
Sensitivity	Na:0.5ppm Li:0.5ppm K: 0.5ppm Ca: 15ppm
Resolution	0.1 ppm
Display	20 x 4 alphanumeric LCD with backlit
Flame system	LPG and dry oil free air
Detector	Silicon photo Diode
Calibration	Up to 5-Point calibration with curve fitting software
Gas cut-off	Automatic
Flame failure	Auto detection
Atomiser	Axial flow type
Ignition system	Auto ignition
Power	230 V $\pm$ 10% AC, 50 Hz
Dimension	285 x 255 x 210 mm
Weight	7.5 kg in approx.



### 7.3. ATOMIC ABSORPTION SPECTROSCOPY:



Fig.7.4. Perkin Elmer AA-200

Atomic Absorption Spectroscopy is a spectro-analytical method of determination of the chemical constituents by the method of absorption of optical radiation with the help of free atoms in the gaseous state.

#### **PRINCIPLE:**

- Before analysis of any sample in an AAS, it needs to be atomised. The atomising process is initiated by atomizers which these days are either flame or electrothermal atomizers. By the virtue of optical radiation, the atoms are then irradiated and the source of the radiation can be line radiation that is specific to element or even a radiation source that is of the continuum form.
- The radiation is then allowed to pass through a monochromator, for the swift separation of element specific radiation, from any radiation that is emitted by the source's radiation. That is finally measured by the detector.

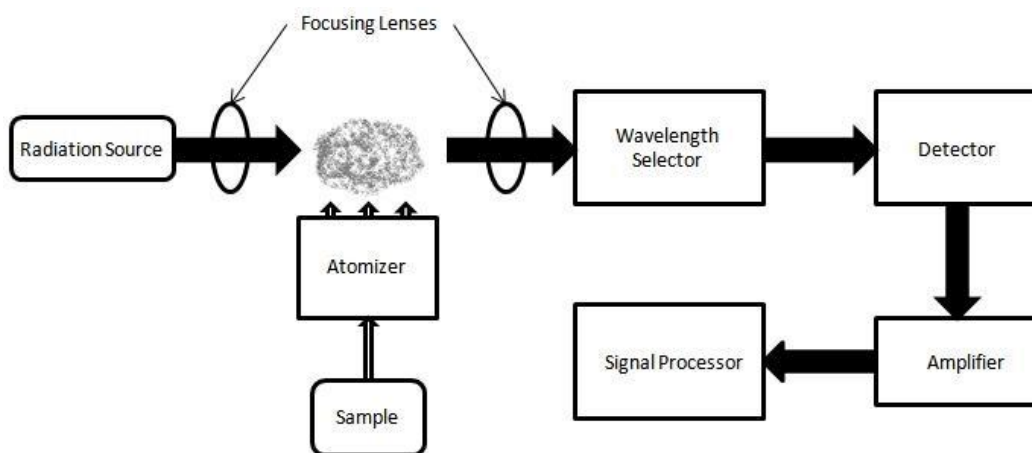


Fig7.5. Mechanism of AAS

Table 7.2. Specifications of the AAS instrument

Type	Specifications
Display	Full-colour 10.4" LCD touch screen
Sample Analysis	Peaks can be displayed and printed when using the MHS-15 accessory
Detector	High efficiency, segmented solid state
Light sources	HCL, EDL
Flame Gas	Fully automated with computer controlled oxidant selection with automatic gas sequencing, oxidant and fuel monitoring.
Flame Safety	Fully interlocked operation prevents ignition if the proper burner head, the nebulizer, end cap or features burner drain system is not correctly installed, the level of the liquid in the drain vessel is incorrect, or gas pressures are too low.
Environmental	Dust free, free of vibrations, ambient temperatures: +15 °C to +35 °C with a change rate of a maximum 3 °C per hour. Relative humidity: 20% to 80% non-condensing.

#### 7.4.SAMPLE PREPARATION:



Fig7.6. Sample Preparation of different ppm

1. A list of all the metals is prepared, for whom the test on AAS and Flame photometry is considered.
2. The standard solution of 100ppm for the metal is taken.
3. To prepare a solution of X ppm, X ml of the standard solution is pipetted into a flask and 100-X ml of distilled water is added to it.
4. This gives us a solution of X ppm.
5. Care is taken to ensure that the solution is exactly 100ml and the standard poured is precisely X ml.
6. The amount of water poured is carefully administered and must be distilled water.
7. In case of the Flame photometry equipment, an extra standard solution is prepared to extrapolate the results with the 3 standards and find the accuracy of the sample preparation.

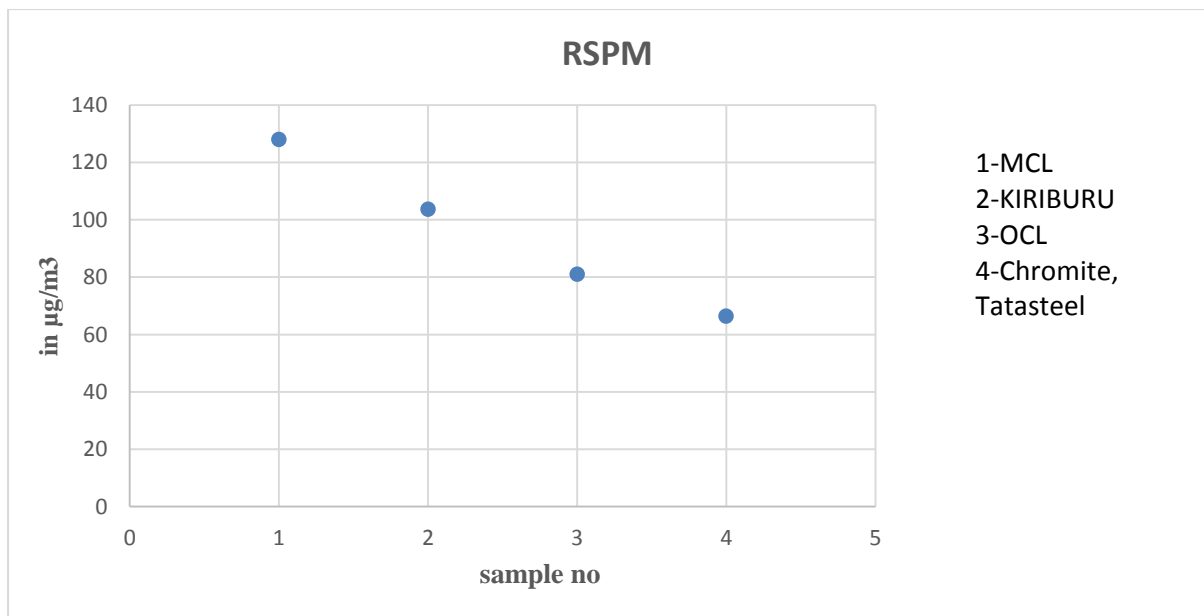
8. In case of AAS, the value of “R” is found out, which is the extent of accuracy of the standard solution prepared. If R approaches the value of 1, then the solutions prepared are fit to be used for the detection of metal content in the sample.

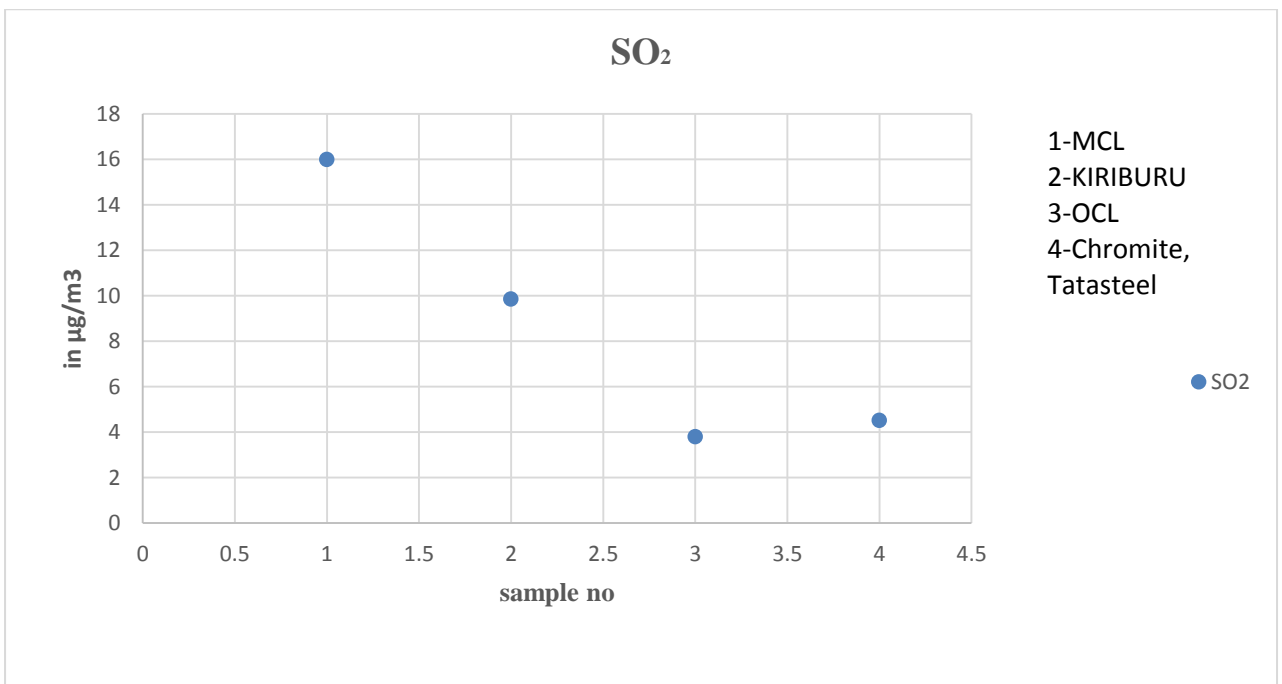
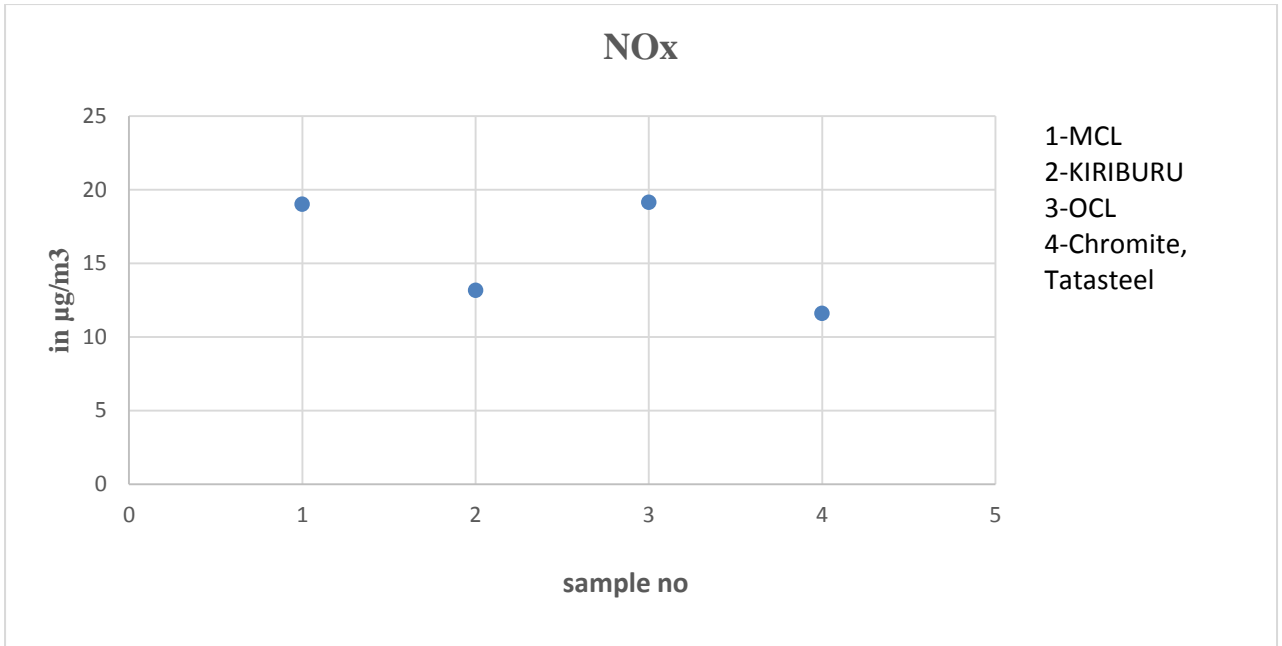


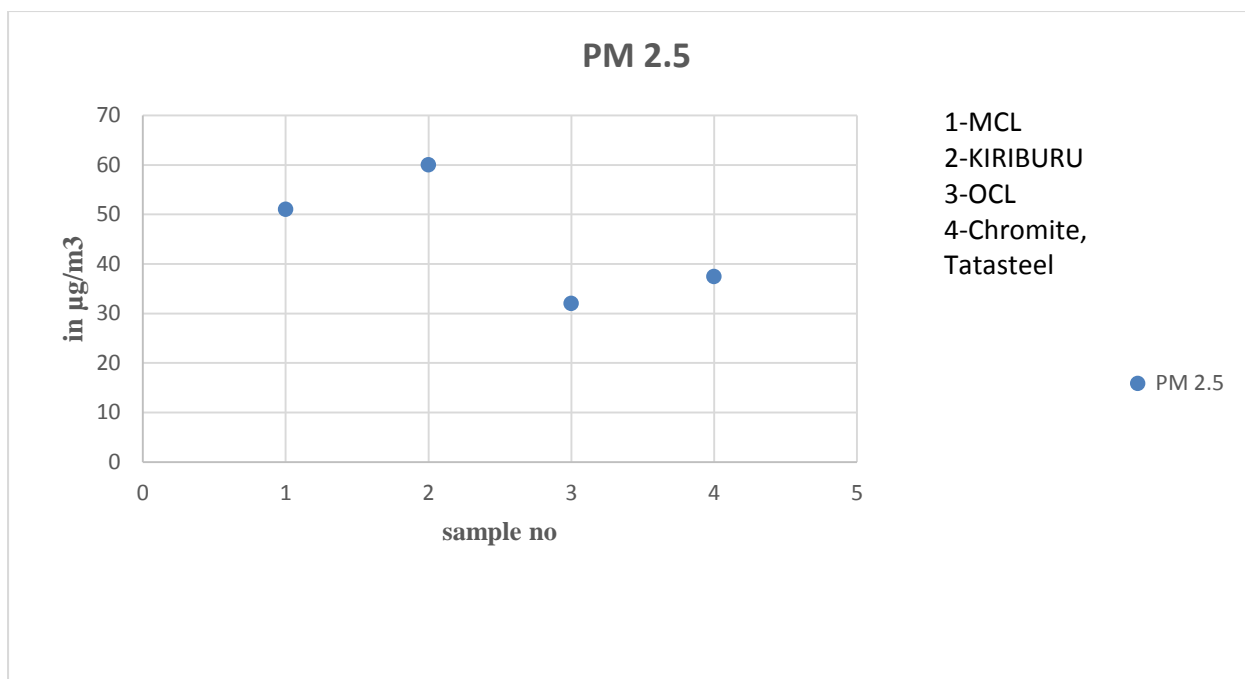
## 8.1.AIR QUALITY RESULTS:

Table 8.1. Air Quality Results:

Parameters-> Samples*	PM <sub>2.5</sub>	RSPM	NOx	SO <sub>2</sub>
s1	51	128	19	16
s2	60	103.6	13.15	9.86
s3	32	81	19.13	3.8
s4	37.44	66.38	11.59	4.51







## 8.2.DISCUSSION ON AIR QUALITY:

For PM<sub>2.5</sub>, the Kiriburu Iron Ore mines of SAIL had the highest measured content of 60µg/m<sup>3</sup>. For Respirable Suspended Dust particulate matter, coal mines of Samaleshwari OCP, MCL had the highest measured amount of 128 µg/m<sup>3</sup>. The highest content of NO<sub>x</sub> production in the study was that of OCL, Lanjiberna at 19.13 µg/m<sup>3</sup>. The coal mines of Samaleshwari OCP, MCL was close to follow it with 19 µg/m<sup>3</sup> of NO<sub>x</sub> content in the air.

The SO<sub>2</sub> content in air was highest for Samaleshwari OCP, MCL at 16 µg/m<sup>3</sup>. Interestingly, of the 4 mines in the study, the SO<sub>2</sub> content in MCL was more than 1.5 times of the second highest reading of Kiriburu, SAIL (9.86 µg/m<sup>3</sup>). In the study of the air quality of the mines, the best air quality performance was that of chromite mines of TATA Steel Sukinda. The chromite mines had the least content of PM<sub>2.5</sub>, RSPM, NO<sub>x</sub> and SO<sub>2</sub> in the study.



### 8.3.WATER QUALITY RESULTS:

**Table 8.2. Physical Parameters:**

Parameters-> Samples*	Temperature	TDS	Conductivity(in mS/cm)	Turbidity(in NTU)
s1-a	18.06	0.124	0.192	2.5
s1b	17.71	0.784	1.22	94.4
s2	20.2	58	0.62	12
s3-a	17.1	0.265	0.408	2.3
s3-b	18.81	0.323	0.505	3.5
s4	21.74	0.264	0.4	1.3

**Table 8.3. Chemical parameters:**

Parameters-> Samples	pH	NO <sub>3</sub> <sup>-</sup>	DO(in mg/l)	DO%	BOD	ORP in mV
s1-a	7.4	3.99	14.01	152.7	2.6	300
s1b	5.36	4.43	13.32	144.7	2.3	170
s2	6.85	10.25	11.3	132.6	2.4	268
s3-a	5.72	0.9314	11.84	126.8	2	292
s3-b	5.52	1.2	10.8	119.6	2.2	306
s4	5.63	0.36	11.27	131.6	7.19	276

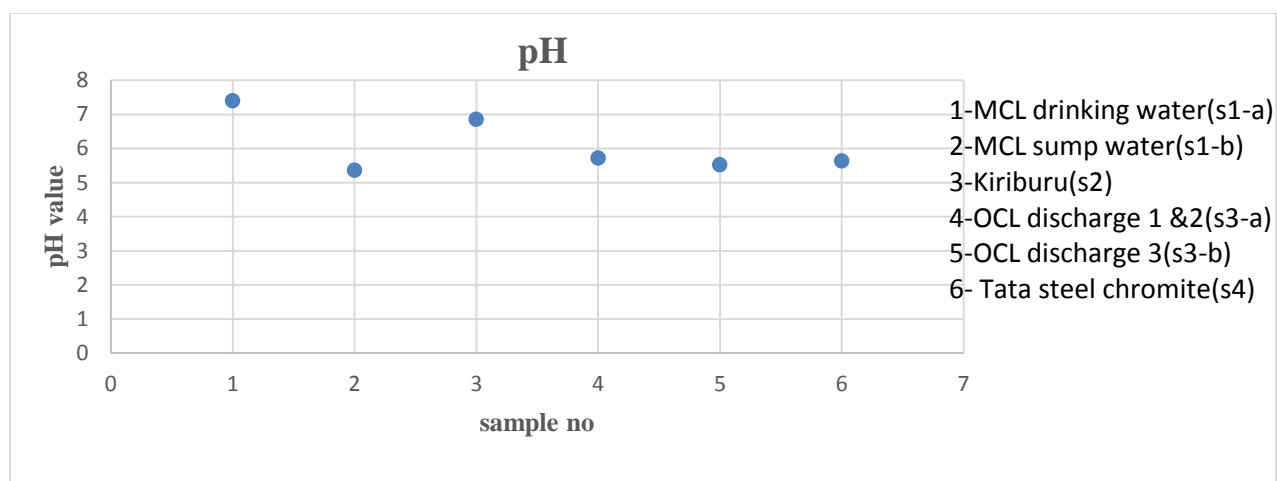
**Table 8.4. Metals Contamination:**

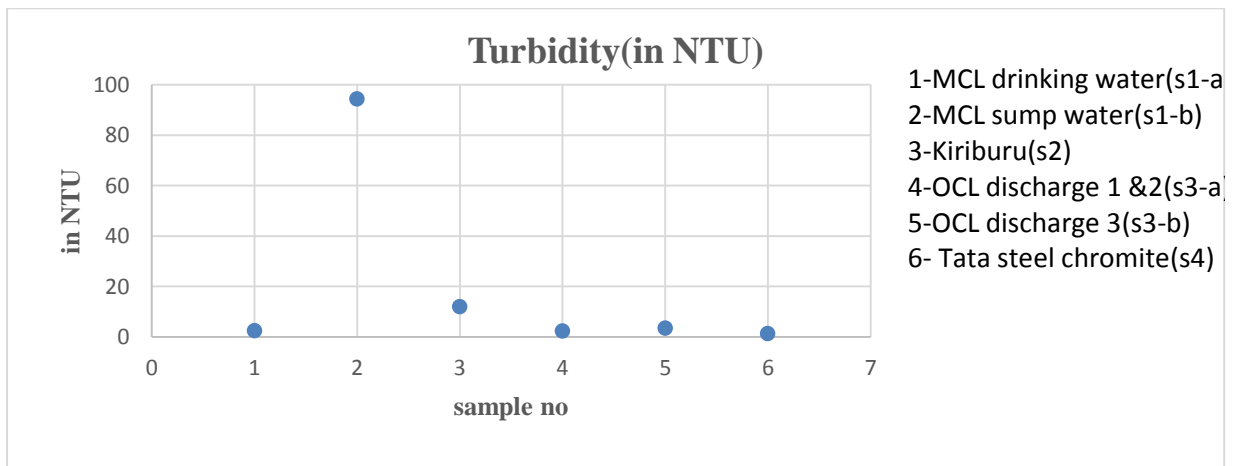
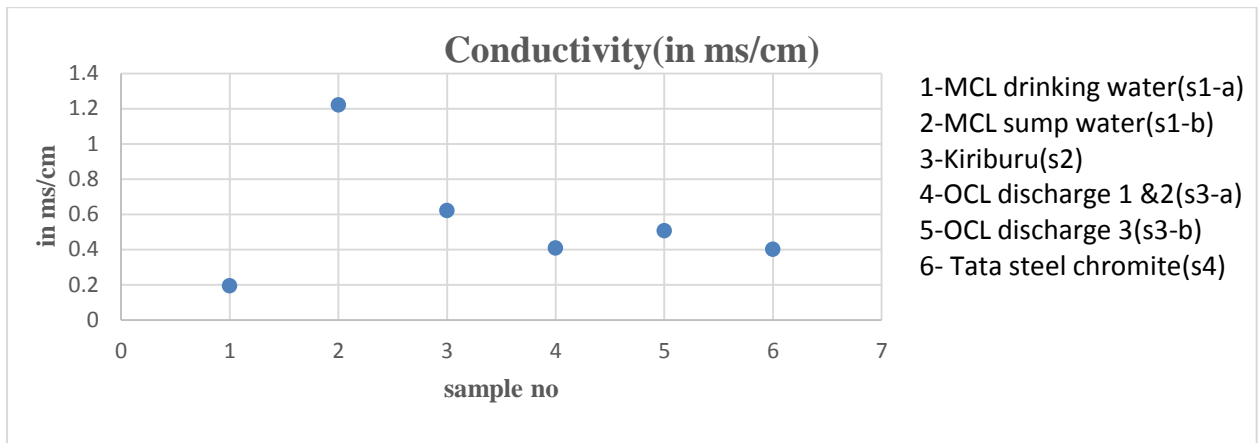
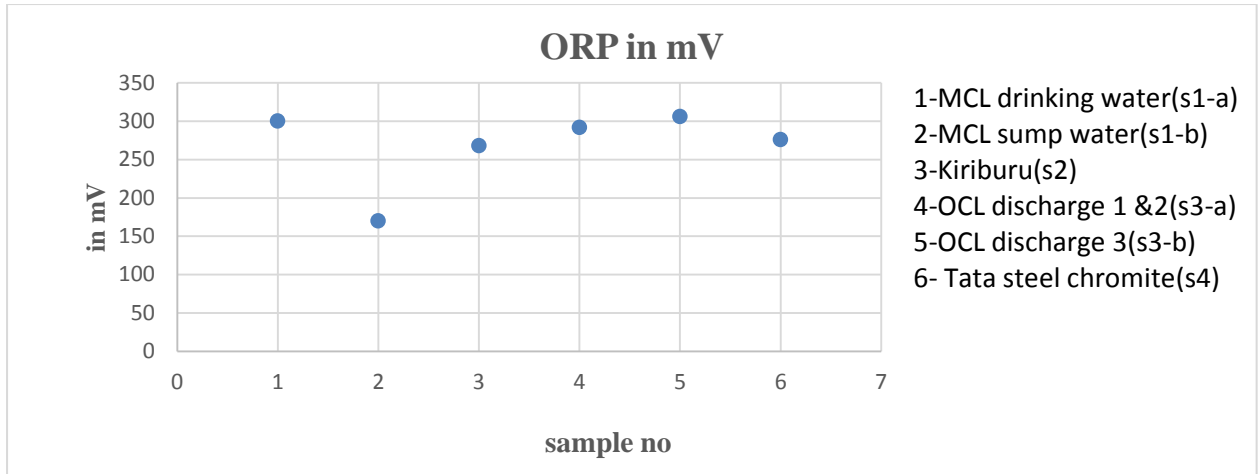
Parameters-> Samples	Na <sup>+</sup>	K <sup>+</sup>	Cu <sup>2+</sup>	Fe <sup>2+</sup>	Zn <sup>2+</sup>	Ni <sup>2+</sup>	Pb <sup>2+</sup>	Hg <sup>+</sup>	Cr <sup>2+</sup>	As <sup>2+</sup>	Cd <sup>2+</sup>
s1-a	0.95	0.28	0.01	0.001	0.006	0.002	BDL	BDL	.001	.021	.005
s1b	1.29	5	0.008	0.082	0.107	0.155	BDL	BDL	.001	.026	.006
s2	0.27	6.11	0.01	0.1	0.002	0.012	BDL	BDL	0	0	0
s3-a	0.74	0.32	0.006	0.086	0	0.004	BDL	BDL	.001	.013	.004
s3-b	0.74	0.48	0.008	0.08	0.008	0	BDL	BDL	.002	.019	.006
s4	0.51	0.32	0.012	0.004	0.002	0	BDL	BDL	1.259	.042	.007

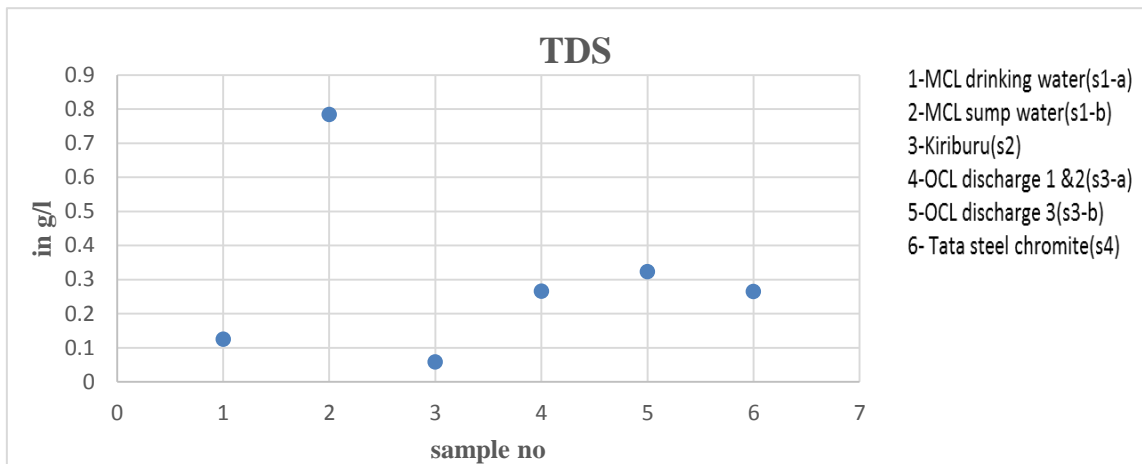
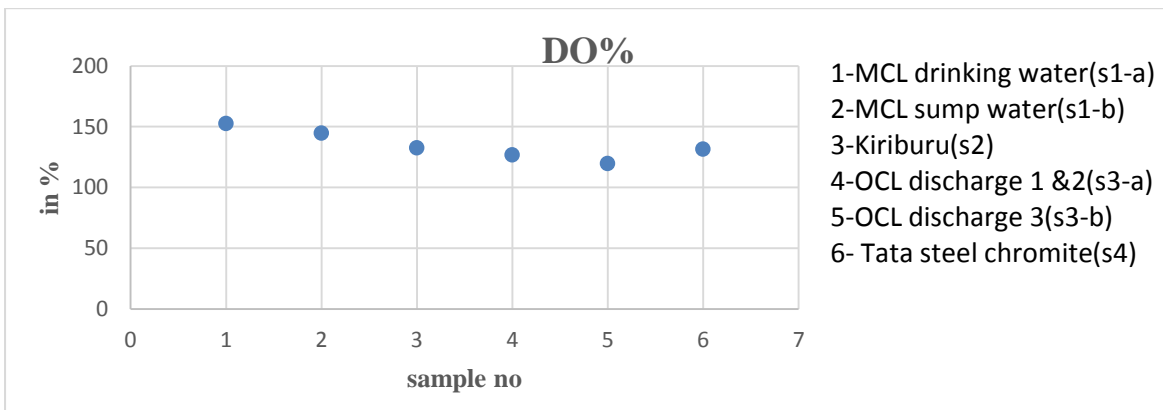
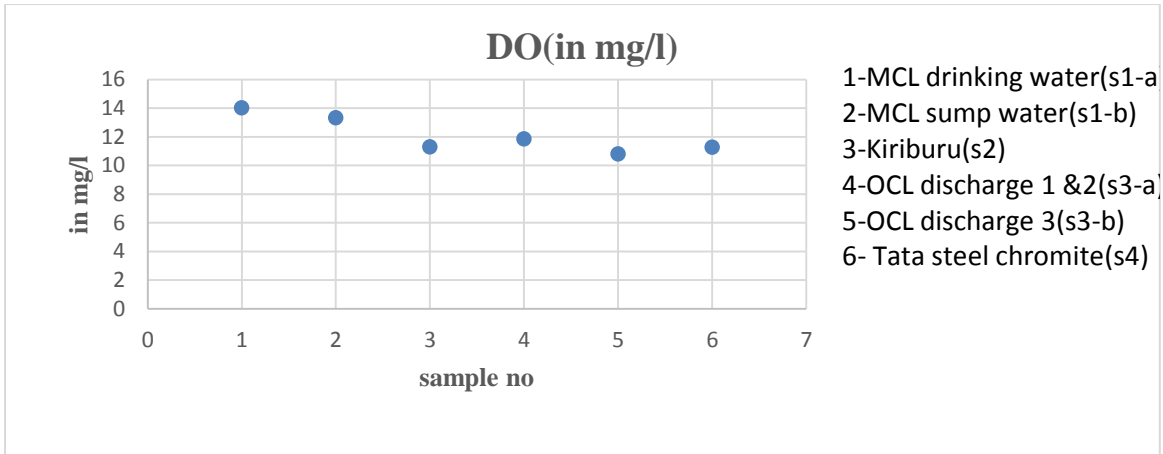
Table 8.5. Sites of sample collection

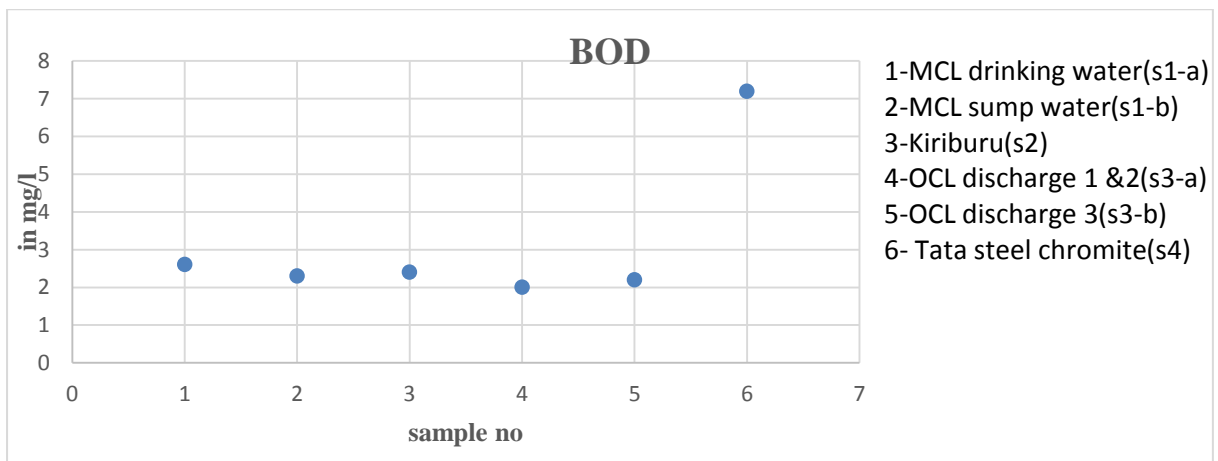
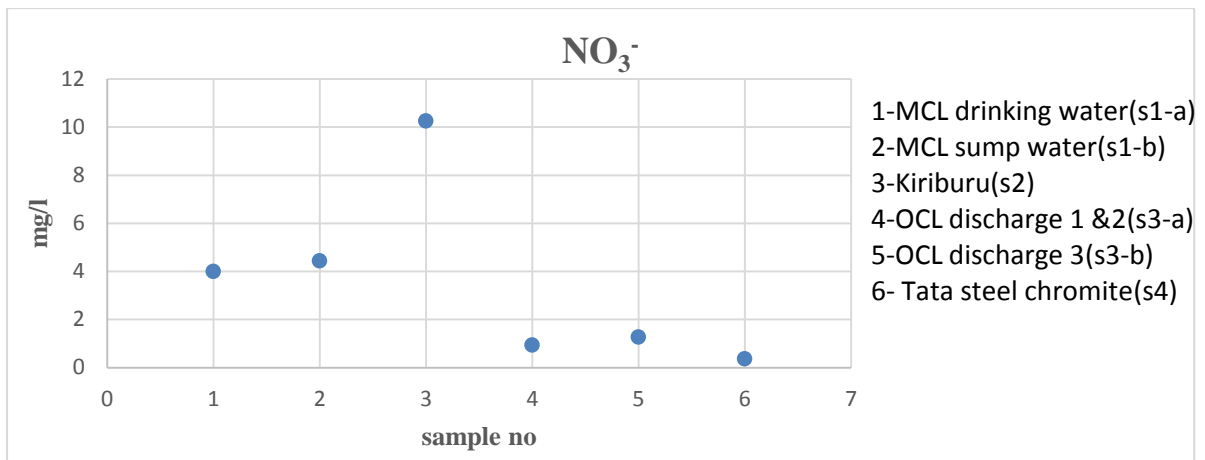
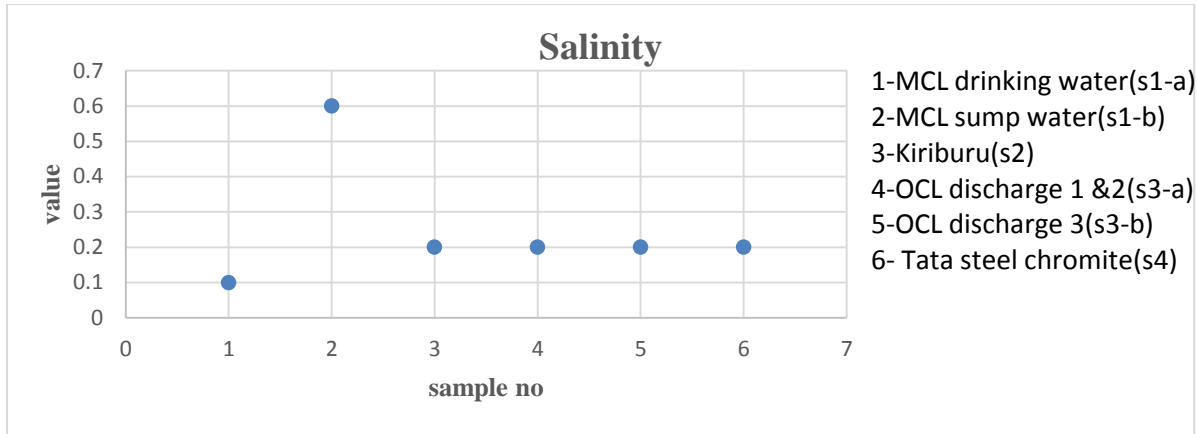
Sl. No	Mines Name	Ore Type	Location of sampling
S-1A	Samaleshwari OCP, MCL	Coal	Drinking Water for the workers
S-1B	Samaleshwari OCP, MCL	Coal	Sump Water
S-2	Kiriburu Iron Ore Mines, SAIL	Iron Ore	Drinking Water near the mines
S-3A	OCL, Lanjiberna	Limestone and Dolomite	Quarry 1&2 discharge water
S-3B	OCL, Lanjiberna	Limestone and Dolomite	Quarry 3 discharge water
S-4	Tata Steel, Sukinda Mines	Chromite	Quarry discharge water

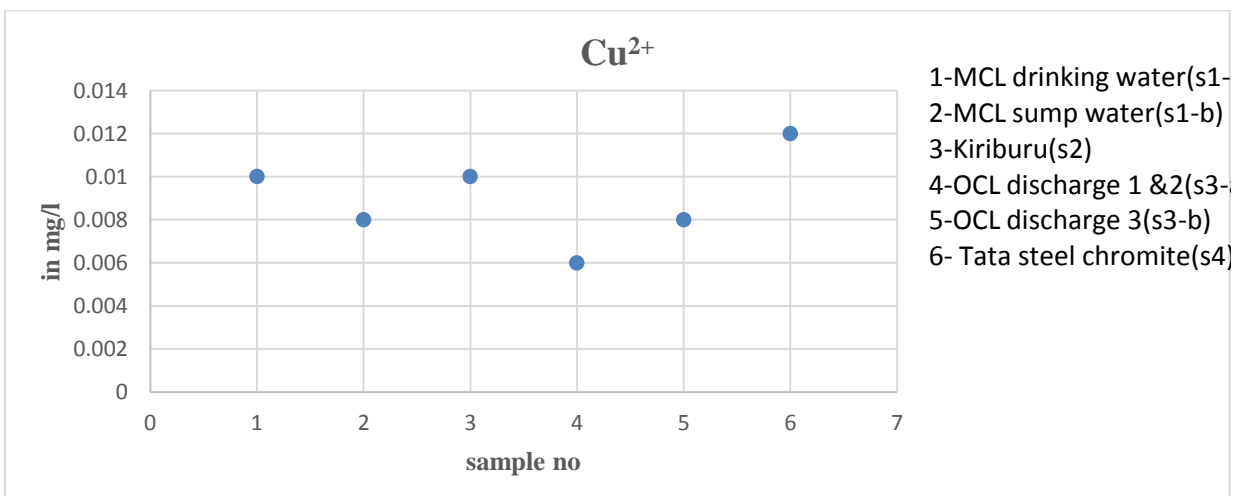
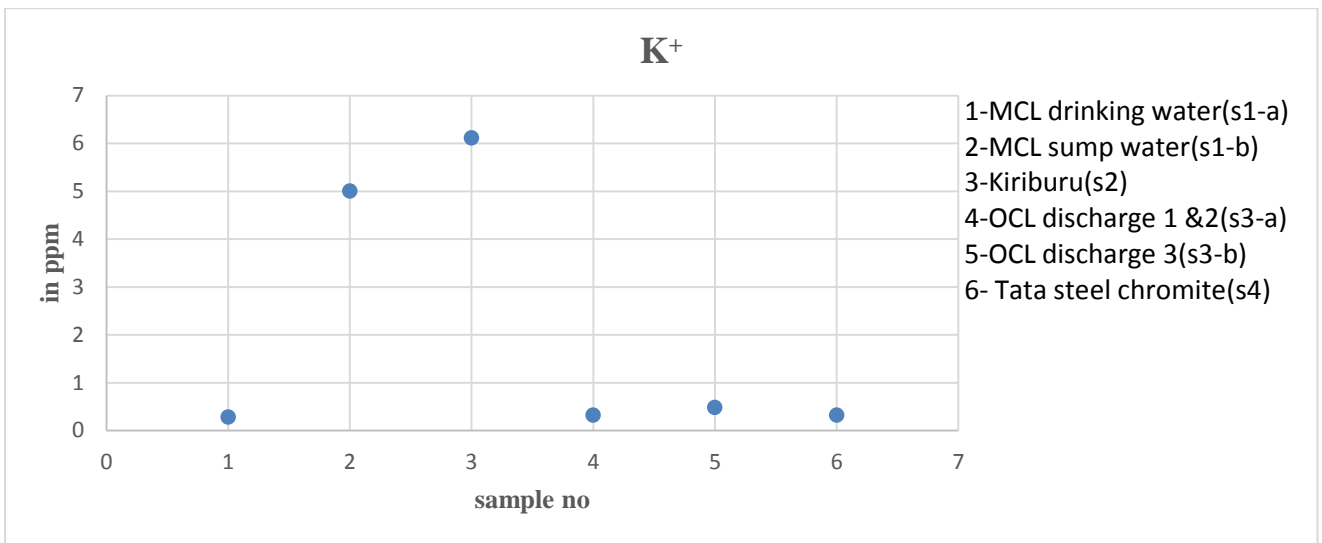
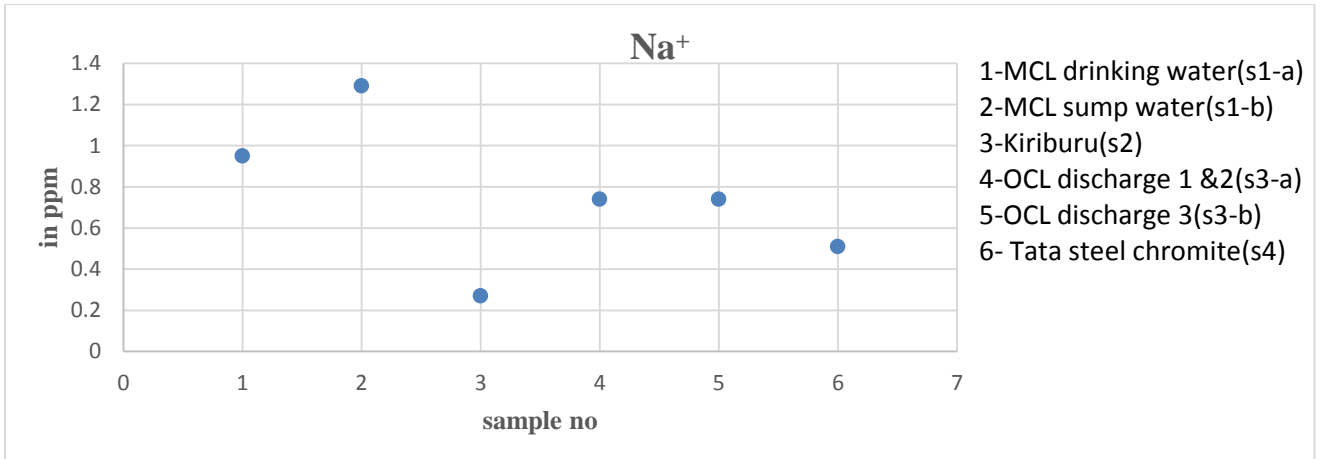
**Graphs:**

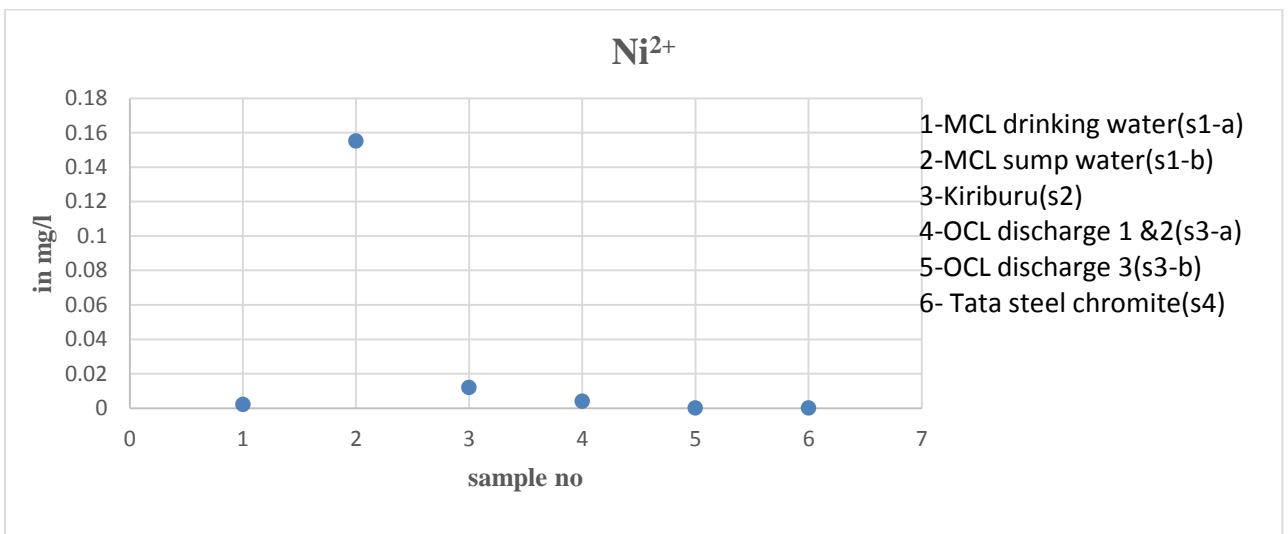
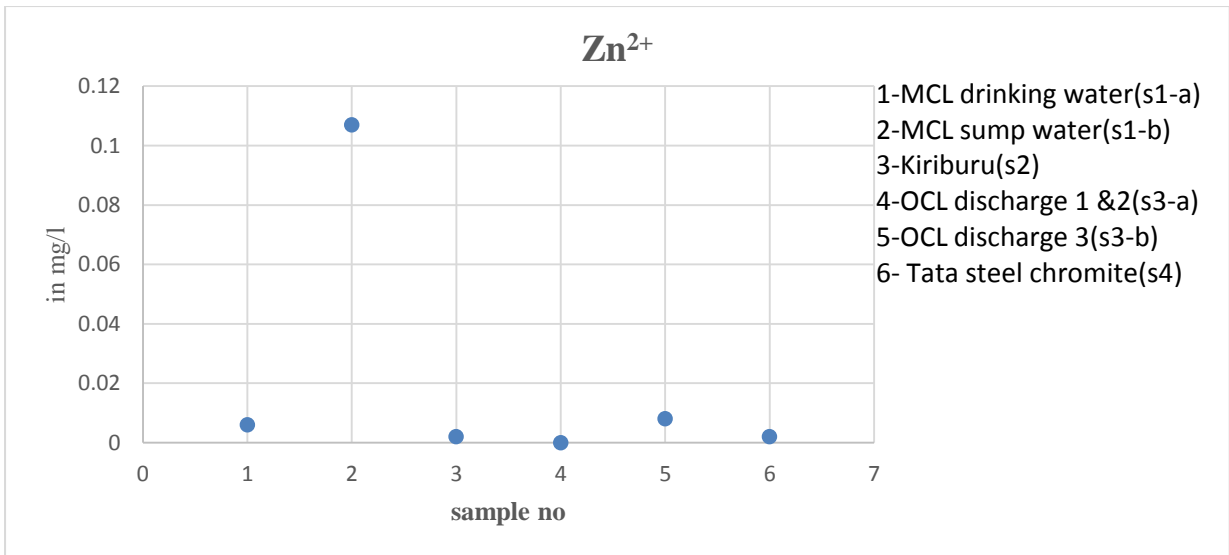
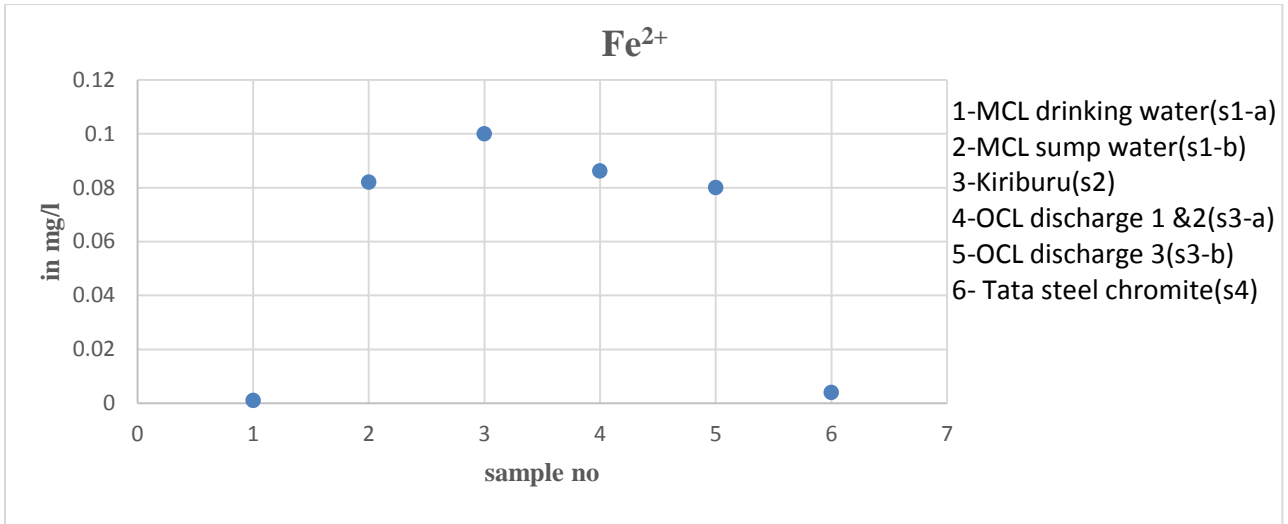


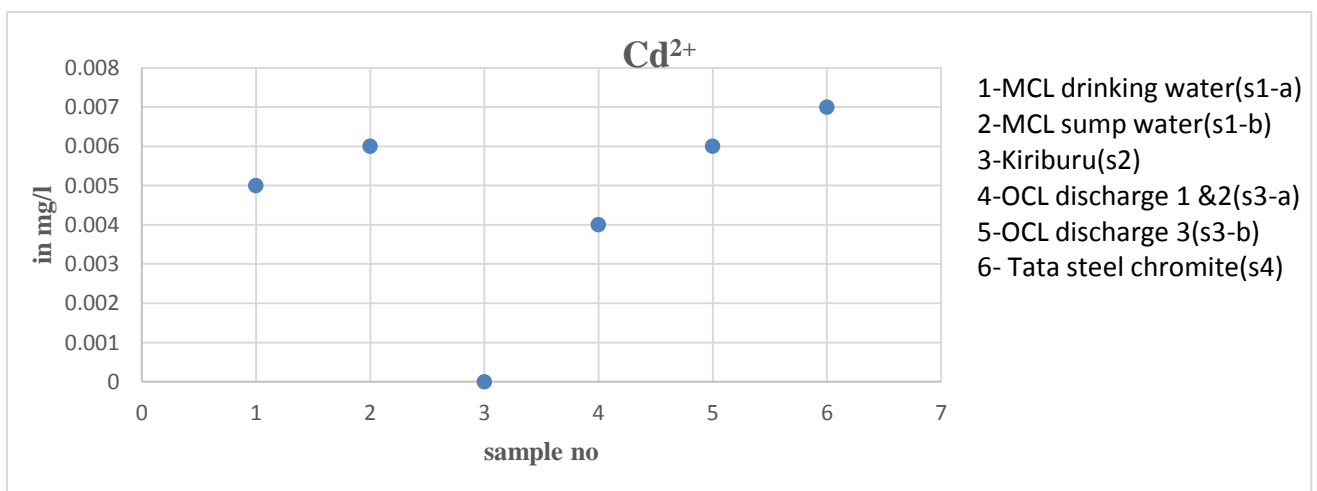
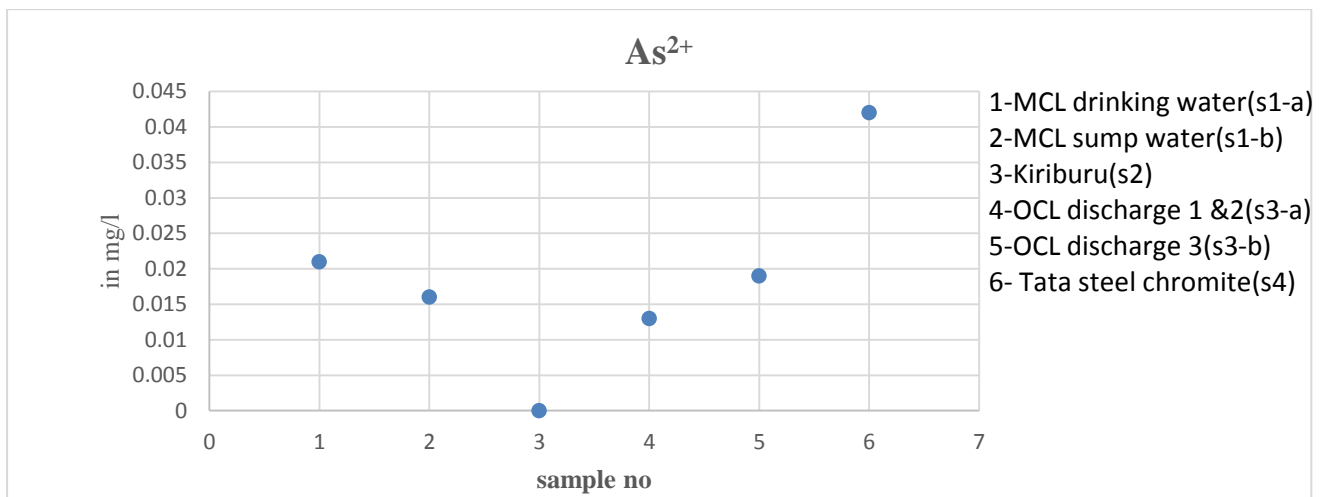
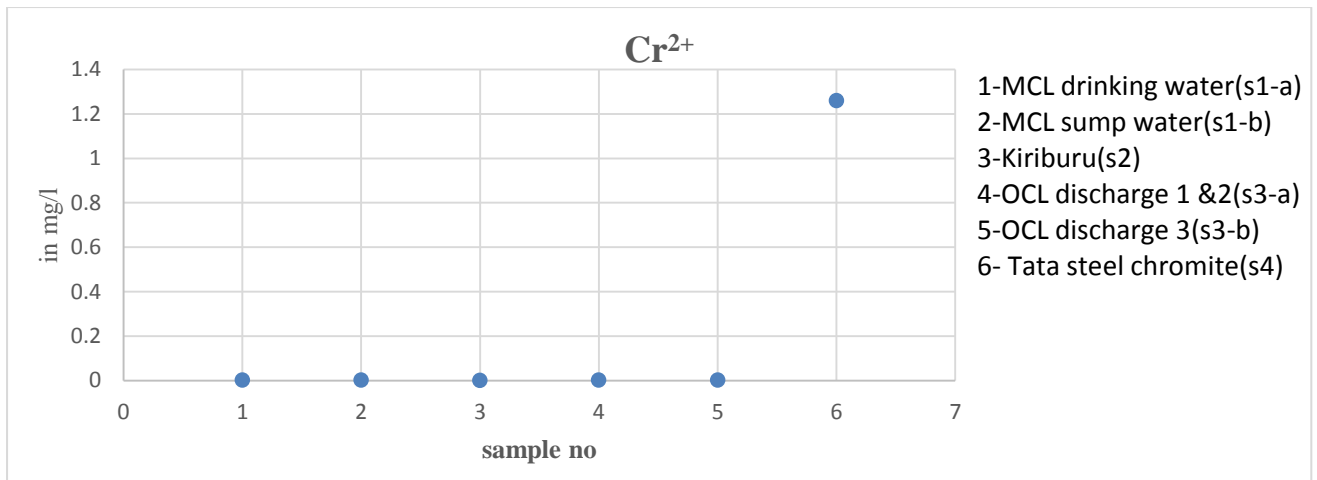














#### 8.4. DISCUSSION ON WATER QUALITY:

On analysis of the physical parameters, it was found that the TDS value for the sump water of Samaleshwari OCP, MCL was highest with 0.784mg/L. Moreover, with greater no of particles in it, both dissolved and suspended, the conductivity was highest for sump water of Samaleshwari OCP, MCL, with a value of 1.22 mS/cm. The conductivity value is more than the second highest value of SAIL by almost two times. The turbidity of the sump water of MCL is staggeringly high at 94.4 NTU, and is much higher than the other mines in the study. The second highest belonged to KIOM, SAIL, with 12 NTU.

A good look at the pH reveals the fact that all the samples in the study, except the drinking water in MCL and drinking point in KIOM, SAIL are acidic in nature. The acidity of the sump water of MCL is highest, with a low pH of 5.36.

The highest content of Nitrate was found in the Iron ore mines of KIOM, with a value of 10.25mg/L. The second highest content of nitrate was in the sump water of MCL, with a value of 4.43mg/L. The value of nitrate in coal mines is understandable with organic content in the mines and its mingling with the water.

The DO level of all the mines varied between 10 to 14 mg/L. The highest DO level was of the drinking water of MCL while the lowest belonged to the quarry 3 water of limestone mines, OCL, with a value of 10.8mg/L.

The BOD level was highest for the sump water of chromite mines of TATA Steel, Sukinda, with a value of 7.19. The BOD level should be preferably under 5mg/L.

The metal content in the water was also analysed and the results were encouraging. None of the samples had any trace of Lead or Mercury in them. The absence of these metals at a harmful level is a positive sign for the aquatic life and ground water.

The sodium level was highest for sump water of MCL, with 1.29mg/L. The potassium level is highest for the drinking water of KIOM, SAIL with 6.11mg per litre. The copper levels are fairly negligible for the majority of the samples and the highest is in the sump water of MCL and sump water of quarry 1 of OCL. The iron levels are expectedly highest in the drinking water of KIOM, SAIL. The levels of Nickel are absent in TATA Steel chromite mines and it is highest in the sump water of MCL. The chromium content is expectedly highest in the chromite mines of TATA Steel, with a value of 1.259mg/L. The

Arsenic content is greater for the chromite mines with 0.042mg/L but it is low according to the permissible standards. The cadmium content is highest again for the sump water of TATA Steel.

### 8.5. WATER QUALITY MODELLING (USING NSF-WQI):

Water quality modelling is a method to quantify the quality of water. It is a numerical model that uses various parameters and determines the quality of water and decides its fitness for different activities. There are 9 parameters that are taken into consideration while determining the water quality:

- Dissolved oxygen (DO)
- Faecal coliform
- pH
- Biochemical oxygen demand (BOD) (5-day)
- Temperature change (from 1 mile upstream)
- Nitrate
- Turbidity
- Total solids
- Total Phosphates

The water quality is estimated as follows from the 8 parameters:

$$\text{NSF WQI} = \frac{\sum QW}{\sum W}$$

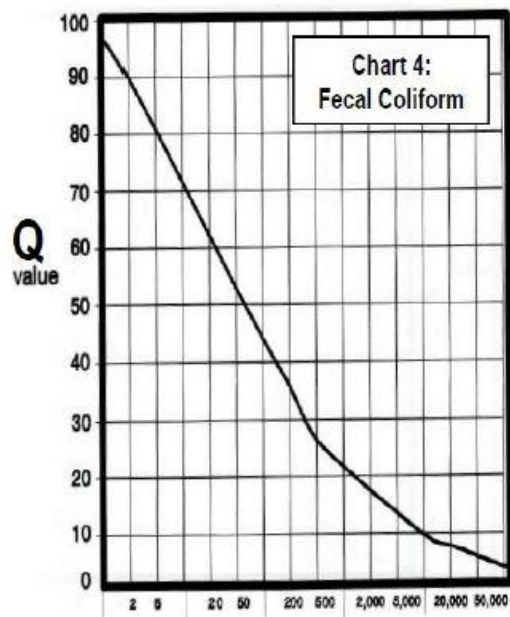
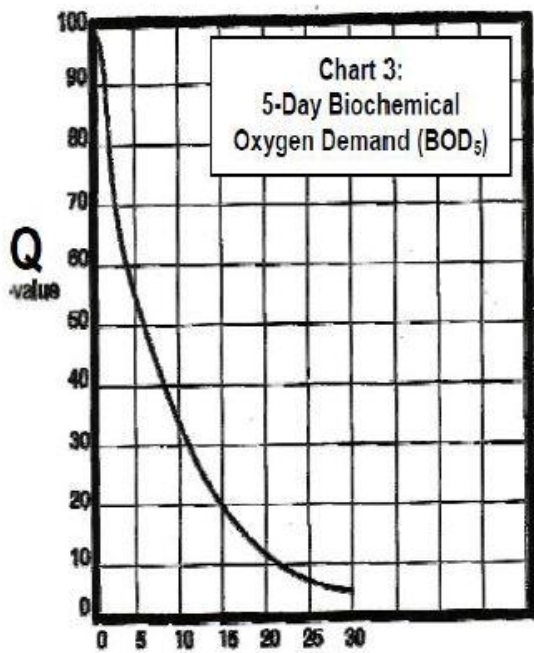
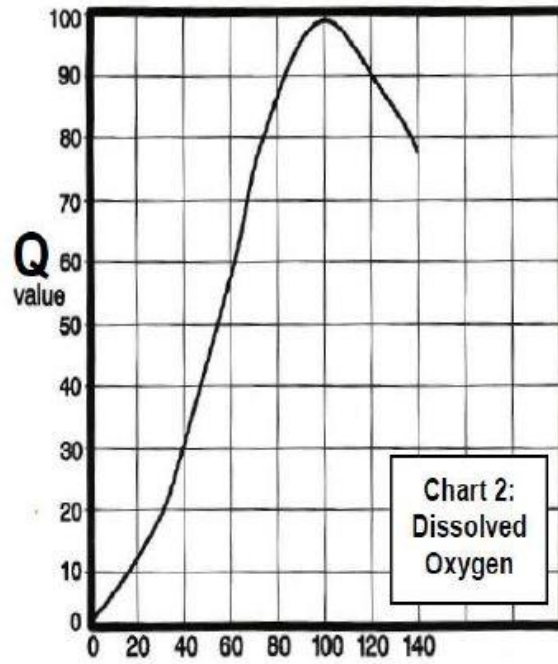
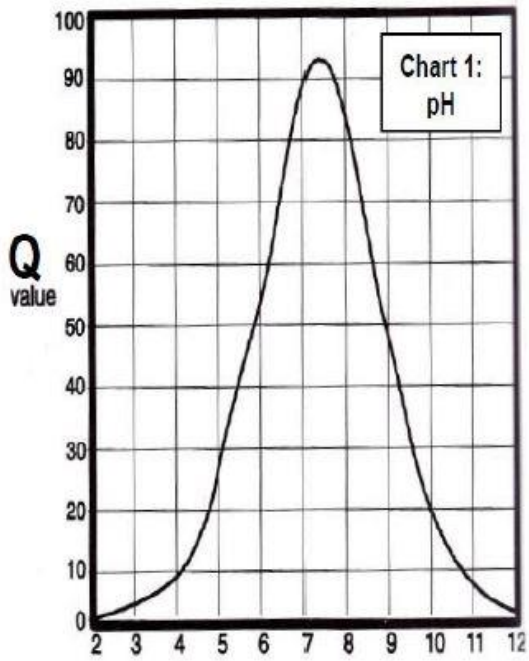
Where Q = quality value of a parameter

And W = weight of that parameter.

Brown and others in 1970 gave the quantification to the quality of water:

Table 8.6. NSF-WQI water quality table

WQI	Water Quality
0-25	Very bad
25-50	Bad
50-70	Medium
70-90	Good
90-100	Excellent



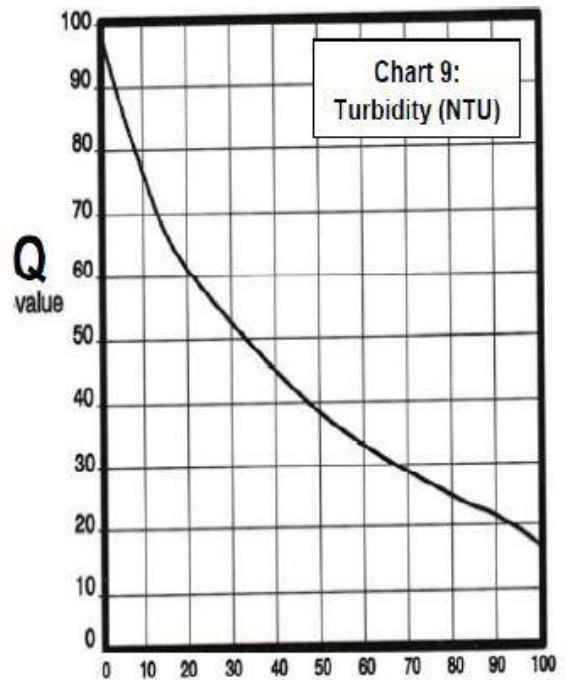
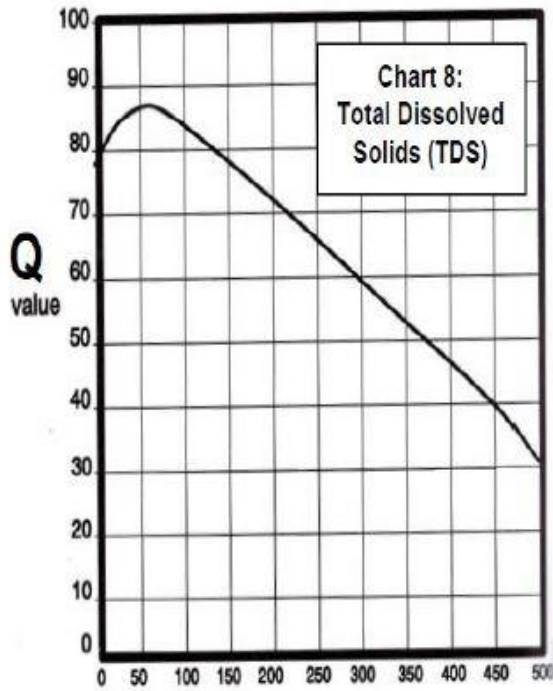
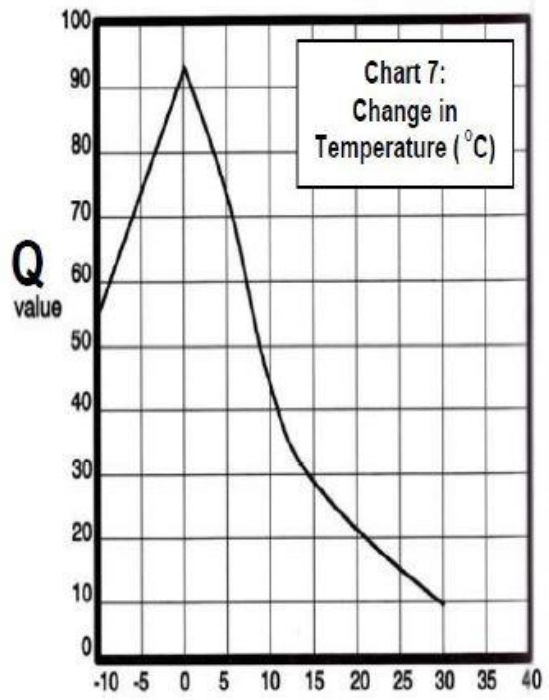
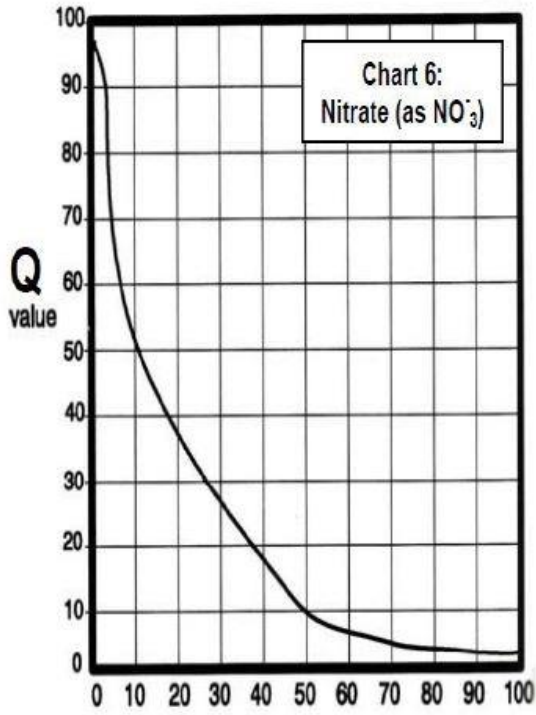


Table 8.7. Weightage of the various factors:

Factor	Weightage
DO	0.17
Faecal Coliform	0.16
pH	0.11
BOD	0.11
Temperature Change	0.10
Total Phosphate	0.10
Nitrates	0.10
Turbidity	0.08
Total Solids	0.07

The results of the WQI values are presented in the following tables:

Table 8.8. MCL Drinking Water: (s1-a)

Parameters	values	Qi	Wi	Qi*Wi
DO(% in saturation)	152.7	73	0.17	12.41
pH	7.4	90	0.11	9.9
BOD	2.6	70	0.11	7.7
Nitrate	3.99	68	0.1	6.8
Turbidity	2.5	86	0.08	6.88
TDS	0.124	81	0.07	5.67
Total			0.64	49.36
WQI				77.125

Table 8.9. MCL Sump Water: (s1-b)

Parameters	values	Qi	Wi	Qi*Wi
DO(% in saturation)	144.7	75	0.17	12.75
pH	5.36	45	0.11	4.95
BOD	2.3	70	0.11	7.7
Nitrate	4.43	65	0.1	6.5
Turbidity	94.4	18	0.08	1.44
TDS	0.784	81	0.07	5.67
Total			0.64	39.01
WQI				60.95

Table 8.10. Kiriburu Iron ore mines: s2

Parameters	values	Qi	Wi	Qi*Wi
DO(% in saturation)	132.6	85	0.17	14.45
pH	6.85	82	0.11	9.02
BOD	2.4	70	0.11	7.7
Nitrate	10.25	51	0.1	5.1
Turbidity	12	60	0.08	4.8
TDS	58	85	0.07	5.95
Total			0.64	47.02
WQI				73.47

Table 8.11. OCL discharge 1&2: s3-a

Parameters	values	Qi	Wi	Qi*Wi
DO(% in saturation)	126.8	87	0.17	14.79
pH	5.72	47	0.11	5.17
BOD	2	67	0.11	7.37
Nitrate	0.9314	92	0.1	9.2
Turbidity	2.3	86	0.08	6.88
TDS	0.265	80	0.07	5.6
Total			0.64	49.01
WQI				76.57

Table 8.12. OCL discharge 3: s3-b

Parameters	values	Qi	Wi	Qi*Wi
DO(% in saturation)	119.6	91	0.17	15.47
pH	5.52	40	0.11	4.4
BOD	2.2	73	0.11	8.03
Nitrate	1.268	85	0.1	8.5
Turbidity	3.5	84	0.08	6.72
TDS	0.323	81	0.07	5.67
Total			0.64	48.79
WQI				76.23

Table 8.13. Tata steel chromite Mines: s4

Parameters	values	Qi	Wi	Qi*Wi
DO(% in saturation)	131.6	85	0.17	14.45
pH	5.63	46	0.11	5.06
BOD	7.19	41	0.11	4.51
Nitrate	0.36	91	0.1	9.1
Turbidity	1.3	90	0.08	7.2
TDS	0.264	80	0.07	5.6
Total			0.64	45.92
WQI				71.75



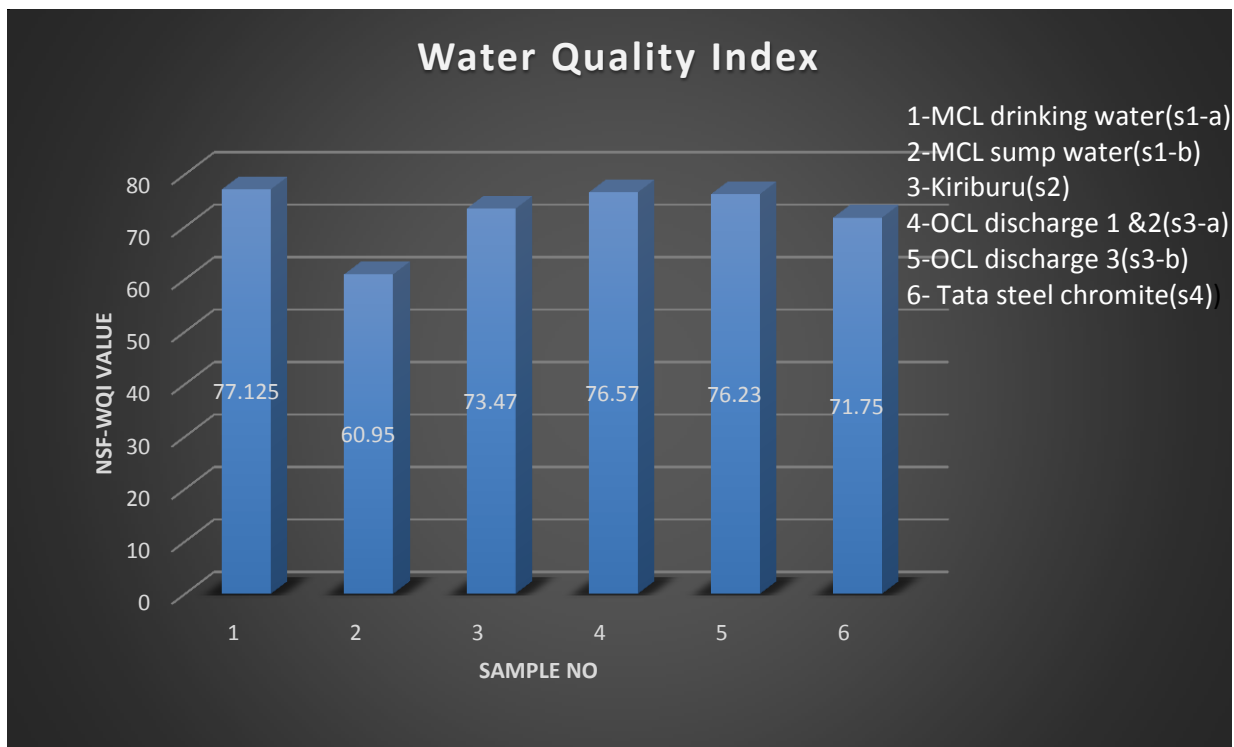


Fig 7.7. NSF-WQI for the water samples

From the water quality index graphs, it can be inferred that the best quality water belongs to the drinking water of MCL (value of 77.123). The water quality can be termed as good and is the best in the study. Following it are the sump water of OCL (76.57&76.23) and the drinking water of SAIL (73.47). The lowest value of the WQI is for the sump water of MCL mines. The value of water quality index for the Samaleshwari OCP, MCL is the lowest with 60.95. The water quality can be termed as medium and might be unfit for consumption.

Encouraging facts are the good quality of the sump water of OCL and TATA Steel chromite mines. Despite being the discharge water, the contamination level in the water is fairly low and is “good” as per the NSF-WQI water modelling standards. The good quality of water even in the sump is probably due to the fact that the limestone and chromite do not have as detrimental effect on water as much as coal. The higher WQI of sump water in OCL and TATA Steel indicates that the level of pollution brought about by limestone and chromite is lower than coal.



Both the air and water quality assessment of the four mines gave encouraging results. While the results revealed that the levels are under permissible limits, yet they have the potential to be detrimental to the environment. The greater level of air quality control at TATA Steel Sukinda mines exemplifies the fact that the other mines need better mitigation and prevention measures to control the dust and fumes in the air. Use of wet drilling and chemicals for dust control in haulage road can go a long way in ensuring that the air quality in mines and nearby regions are not harmful enough for the humans living and working nearby.

As far as the water quality is concerned, most of the mines have good quality of water. The chromite content in the sump water of Tata Steel is higher and must be treated properly before it is allowed to mix with any other water bodies. The pH of most of the samples were lower than 7 and can be alarming if the water happens to mingle with any other source of drinking water or ground water. The water from the mines should be preferably treated properly before being discharged.



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