vedanta
transforming elements

**SPEED POST**

Ref : HZL/Kayad/ENV/MOEF/2021-22/011 May 12, 2021

**To,**

**The Director,**
**Regional Office, (Central Region)**
**Ministry of Environment, Forest and Climate Change**
**Kendriya Bhawan, 5th floor,**
**Sector- H, Ali ganj**
**LUCKNOW (UP)-226024**

**Sub: Six monthly environmental compliance report from October 2020 to March 2021.**

**Ref : Env clearance vide No. : J-110115/47/2012-IA.II (M) dated 5th Feb, 2018.**

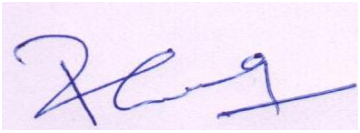
Dear Sir / Madam,

Please find enclosed herewith the compliance status report of above referred Environmental Clearance granted by the Ministry of Environment, Forest and Climate Change for the period of October 2020 to March 2021 is for your kind perusal. Soft copy of compliance is also mailed and uploaded in the website.

Hope you find this in order.

Thanking you,

Yours faithfully



**(K.C. Meena)**
**Director- SBU Kayad Mine**

Cc to:

1. In-Charge ( Zonal office)
   Central Pollution Control Board
   Zonal Office (Central)
   3rd Floor, Sahkar Bhawan,
   North T.T. Nagar,
   Bhopal – 462 003 (MP)
2. Member Secretary
   Rajasthan Pollution Control Board
   4 Institutional Area, Jhalana doogri
   Jaipur (Raj)

# Hindustan Zinc Limited
# Kayad Mine, Ajmer

## Environment Clearance Compliance Report: -

**Name of the project: Kayad Lead- Zinc Underground Mine, M/S Hindustan Zinc Limited, Village kayad, Distt. Ajmer, Rajasthan.**
**Environmental Clearance letter no: J-11015/47/2012-IA.II (M) dated 5th Feb, 2018.**
**Period of Compliance report: October 2020 – March 2021**

| S.no | A. Specific Conditions | Compliance Status |
|---|---|---|
| 1. | Environmental Clearance is Granted Subject to Under Hon'ble Supreme Court Judgment Date 02.08.2017 | Noted |
| 2. | Environmental Clearance is Granted Subject to Final Outcome of Hon'ble Supreme Court of India, Hon'ble High Court of Rajasthan and other Court of Law, if any, as May be Applicable to this project . | Noted |
| 3. | This Environmental Clearance is subject to obtaining Requisite NBWL Clearance from the Standing Committee of National Board for Wildlife, if any, Applicable for this Mining Project | Not Applicable |
| 4. | No Mining Activities Will be Allowed in Forest area, if any, for which the Forest Clearance is not Available. | No forest involved in mine lease area |
| 5. | This Project Shall obtain Consent to Operate from the State Pollution Control Board, Rajasthan and effectively implement all the Conditions Stipulated therein. | Consent to Operate was granted by Rajasthan State Pollution Control Board Vide lr no. F(Mines)/Ajmer(Ajmer)/303(1)/ 2017-2018 / 9550 - 9554 dated 17.02.2018<br>All the conditions are being implemented effectively. |
| 6. | The Proponent should install online Ambient Air Quality Monitoring System and there should be system for display of digital AAQ data within 03 months at least at three locations as per wind direction. Online provisions of pH and Turbidity meters at discharge points of STP and ETP and also at water storage ponds in the mining area may be made; Project Proponent should display the result digitally in front of the main Gate of the mine site. | Online Ambient Air Quality Monitoring system installed and AAQ data digital displayed outside gate.<br>pH and Turbidity meters at STP discharge point is also installed and result digitally displayed at outside gate of mine site. |
| 7. | The Project Proponent has to take care of gullies formed on slopes. Dump mass should be consolidated with proper filling/leveling with the help of dozer/compactors. The report on slope and stability | Waste generated from Mining operations is being reused for back filling. No waste is accumulated at site. |

Sensitivity: Internal (C3)

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| | monitoring should be sent to MoEF & CC and its Regional office every six-month. | |
| 8. | The reclamation at waste dump sites shall be ecologically sustainable. Scientific reclamation has been followed. The local species may be encouraged and species are so chosen that the slope, bottom of the dumps and top of the dumps are able to sustain these species. The aspect of the dump is also a factor which regulates some climatic parameters and allows only species adapted to that micro climate. This may be recommended to be studied by hiring Expert Ecology Group. | Waste generated from Mining operations is being reused for back filling. No waste is accumulated at site. |
| 9. | There is need for regular monitoring of invertebrates and aquatic life of water bodies including the reservoir located close to the mining lease to establish that fish and other animals including the water is not 'contaminated with heavy metal. There could be a research on "bio accumulation of heavy metals in invertebrates" to completely establish that there is no impact of mining. | Report enclosed as **Annexure I** |
| 10. | A specialized Institution may be hired to carry out ecological survey on the plant species to evaluate their growth in terms of stunted, deformed and seed viability. The sensitive species and indicator species to heavy metal pollution may be screened out and plantation accordingly designed. Similarly, uptake of Zinc, Cadmium and lead etc. by crops and vegetables grown in the crop lands around the mining lease may be studied. Bottom sediment analysis of ponds, wells and Rivers to ascertain the level of accumulation of heavy metal may be done. | A specialized institution M/s National Environmental Engineering Research Institute (NEERI), Nagpur carried out ecological survey.<br>Report enclosed as **Annexure-I** |
| 11. | The Proponent shall conduct an Occupational health study with respect to the pressure impact on ear drums as person goes underground and implement the recommendations. | Occupational health study with respect to the pressure impact on ear drums as person goes underground conducted inhouse and implemented the recommendations.<br>Report already submitted. |
| 12. | Project Proponent shall carry out vibration studies well before approaching any such habitats or other buildings to evaluate the zone of influence and impact of blasting on the neighborhood. Within 500 meters of such sites vulnerable to blasting vibrations, avoidance of use of explosives and adoption of alternative means of mineral extraction. A provision for monitoring of each blast | Blasting being carried out during day time only and the vibration study is being done regularly by M/s CIMFR, Dhanbad.<br>Peak Particle Velocity within 500 meters is ranging between 1.0 - 5.0 mm/second (Limit is |

Sensitivity: Internal (C3)

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| | should be made so that the impact of blasting on nearby habitation and dwelling units could be ascertained. The covenant of lease deed under Rule 31 of MCR 1960 provides that no mining operations shall be carried out within 50 meters of public works such as public roads and buildings or inhabited sites except with the prior permission from the Competent Authority. | 15mm/second) and due care is taken in blast design, explosives use, selection of detonators and delay to ensure safe vibration limit and effective implementation of CIMFR Dhanbad recommendation.<br>No secondary blasting being carried out at site. |
| 13. | Main haulage road in the mine should be provided with permanent water sprinklers and other roads should be regularly wetted with water tankers fitted with sprinklers. The material transfer points should invariably be provided with Bag filters and or dry fogging system. Belt-conveyors should be fully covered to avoid air borne dust; Use of effective sprinkler system to suppress fugitive dust on haul roads and other transport roads shall be ensured, | Mine haul roads in the mine being watered through sprinklers. Effective sprinkling system is in place to suppress fugitive dust on haul road. |
| 14. | The monitoring of PM2.5 in the vehicle emission shall be conducted to improve the mine environment and report submitted to the Regional Office of the MoEFCC. | The monitoring of PM2.5 in ambient air near vehicular movement is conducted but not able to monitor PM 2.5 in vehicular emission due unavailability of technology/ instruments. |
| 15. | The Project Proponent reported that there are seven Schedule-1 species viz. Peafowl (Pavo cristatus), Osprey (Pandion haliaetus), Tawny eagle (Aquila rapax), Crested honey buzzard (Pernisptilorhynchus), Shikra (Accipiter badius), Leopard (Pantherapardus), Indian pangolin (Manis crassicaudata) in the study area. The PP shall implement the Conservation Plan and enhance the budget for implementation of Conservation Plan for Schedule I Specie and also increase the budget for plantation/green development. The Proponent shall implement the Wildlife Conservation Plan along with the funds so allocated with consultation of Chief Wild Life Warden of the State Govt. A copy of action plan shall be submitted to the Ministry of Environment, Forest and Climate Change and its Regional Office, Lucknow and the Chief Wild Life Warden of the State Govt. | Conservation plan has been developed for Schedule-1 namely Peafowl (Pavo cristatus) and has been approved by the additional Principal Chief Conservation of Forest and Chief wildlife warden Jaipur, Rajasthan and implemented the same.<br><br>Action plan along with its implementation status report being submitted to RO MOEF & CC & Chief wild life warden of State Government. |
| 16. | Proponent shall carry out monitoring of lead in the blood samples of the employees and the villagers in the areas surrounding the mine in their schedule of health check-up. The nearby water bodies shall be monitored every six months and report submitted to Regional office of the MoEFCC to ascertain impact due to lead contamination. | The Health checkups of villagers will conduct after normalizing the Covid situation.<br>Water samples analysis of nearby water bodies carried out regularly. |
| 17. | Implementation of Action Plan on the issues raised during the Public Hearing shall be ensured. The Project Proponent shall | Being implemented |

Sensitivity: Internal (C3)

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| | complete all the tasks as per the Action Plan submitted with budgetary provisions during the Public Hearing. | |
| 18. | Implementation of the outcome of study with regard to "optimization of blast design parameter for the safety and stability of surface structures and subsequent monitoring of vibration on the surface structures for their long term stability" which was carried out by Central Institute of Mining and Fuel Research should be ensured. | The Implementation of CIMFR study report is being ensured.<br>• Regular vibration studies conducted through CIMFR<br>• Peak Particle Velocity within 500 m ranging between 1.0 to 5.00 mm/sec (limit 15mm/sec)<br>• Due care is taken in blast design, explosives use, selection of detonators and delay to ensure safe vibration limit. |
| 19. | Continuous monitoring of radioactive elements, if any, shall be undertaken till entire mine is dewatered and report has to be submitted to MoEFCC Regional Office. Periodic monitoring of any adverse impact of Radon and its daughter products on any worker should be included in the Occupational Health Monitoring Programmed. | The monitoring of radioactive element done. The report already submitted. |
| | **B. Standard conditions** | |
| 1. | A Final Mine Closure Plan along with details of Corpus Fund shall be submitted to the Ministry of Environment, Forest and Climate Change 5 years in advance of final mine closure for approval. | A Final Mine Closure Plan along with details of Corpus Fund shall be submitted 5 years in advance. |
| 2. | No change in mining technology and scope of working should be made without prior approval of the Ministry of Environment, Forest and Climate Change. | Assured to comply |
| 3. | No change in the calendar plan including excavation, quantum of mineral and waste should be made. | Being ensured as per Mine Plan. |
| 4. | The project proponent shall obtain necessary prior permission of the competent authorities for drawl of requisite quantity of water (surface water and ground water) for the project. | Renewal application submitted for permission. Recommendation by CGWB to CGWA done. NOC approval due |
| 5. | Mining shall be carried out as per the provisions outlined in mining plan approved by Indian Bureau of Mines (IBM) as well as by abiding to the guidelines of Directorate General Mines Safety (DGMS). | Ensuring the Mining as per the Mine Plan approved by IBM and as per the guideline of DGMS |
| 6. | The lands which are not owned by Proponent, mining will be carried out only after obtaining the consents from all the concerned land owners as per the provisions of the Mineral Concession Rules, 1960 and MMDR Act, 1957. | Ensured to comply |
| 7. | Digital processing of the entire lease area using remote sensing technique shall be carried out regularly once in three years for monitoring land use. Pattern and report submitted to Ministry of Environment, Forest and Climate Change its Regional Office. | Digital processing of the entire lease area using remote sensing technique carried out M/s SRSAC Jodhpur and Report already submitted**.** |
| 8. | The critical parameters as per the Notification 2009 such as Pm, .10,. PM 2.5 NOx and Sox etc. in the ambient air within | The critical parameters such as PM10, PM 2.5, NOx and Sox etc. in |

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| | the impact zone, peak particle velocity at 300m distance or within the nearest habitation, whichever is closer shall be monitored periodically. Further, quality of discharged water shall also be monitored [(TDS, DO, PH and Total Suspended Solids (TSS)]. The monitored data shall be uploaded on the website of the company as well as displayed on a display board at the project site at a suitable location near the main gate of the Company in public domain. The circular No. 3-20012/1/2006-IA.II (M) dated 27.05.2009 issued by Ministry of Environment, Forest and Climate Change shall also be referred in this regard for its compliance. | the ambient air are being monitored within the impact zone, peak particle velocity at Kayad Village being monitored regularly. Zero discharge is being maintained. PM 10, PM 2.5, NOx monitoring data and peak particle velocity data are being uploaded on website of the company as well as display board on main gate of the company. |
| 9. | Effective safeguard measures such as regular water sprinkling shall be carried out in critical areas prone to air pollution and having high levels of Phyllo and PM2.5 such as haul road, loading and unloading point and transfer points. Fugitive dust emissions from all the sources shall be controlled regularly. It shall be ensured that the Ambient Air Quality parameters conform to the norms prescribed under National Ambient Air Quality Standards (NAAQS) or by the Central Pollution Control Board in this regard. Monitoring of Ambient Air Quality to be carried out based on the Notification 2009, as amended from time to time by the Central Pollution Control Board. | An effective safeguard measure has been taken and regular water spraying on the haul road, loading and unloading area are being carried out.<br>Ambient Air Quality parameters maintained and monitored as per National Ambient Air Quality Standards (NAAQS) or by the Central Pollution Control Board. Monitoring data enclosed as **Annexure-II** |
| 10. | Regular monitoring of ground water level and quality shall be carried out in and around the mine lease by establishing a network of existing wells and constructing new piezometers during the mining operation. The project proponent shall ensure that no natural water course and/or water resources shall be obstructed due to any mining operations. The monitoring shall be carried out four times in a year pre-monsoon (April-May), monsoon (August), post-monsoon (November) and winter (January) and the data thus collected may be sent regularly to Ministry of Environment, Forest and Climate Change and its Regional Office, Central Ground Water Authority and Regional Director, Central Ground Water Board. | Regular monitoring of ground water level and quality is being carried out in and around the mine lease by establishing a network of existing wells and piezometers. No natural water course / water resources obstructed due to mining operations. The Water level as **Annexure -III** and water quality data attached **as Annexure – IV & V** |
| 11. | Regular monitoring of the flow rate of the springs and perennial allays flowing in and around the mine lease shall be carried out and records maintain. The natural water bodies and or streams which are flowing in an around the village, should not be disturbed, The Water Table should be nurtured so as not to go down below the pre-mining period. In case of any water scarcity in the area, the Project Proponent has to provide water to the villagers for their use. A provision for regular monitoring of water table in open dug wall located in village should be incorporated to ascertain the impact of mining over ground water table. | No springs and perennial allay flowing in and around the mine lease. |

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| 12. | Regular monitoring of water quality upstream and downstream of water bodies shall be carried out and record of monitoring data should be maintained and submitted to the Ministry of Environment, Forest and Climate Change and its Regional Office, Central Ground Water Authority, Regional Director, Central Ground Water Board, State Pollution Control Board and Central Pollution Control Board. | Regular monitoring of water quality upstream and downstream of water bodies carried out and analysis report Enclosed **Annexure-V** |
| 13. | Transportation of the minerals by road passing through the village shall not be allowed. A 'bypass' road should be constructed (say, leaving a gap of at least 200 meters) for the purpose of transportation of the minerals so that the impact of sound, dust and accidents could be mitigated. The project proponent shall bear the cost towards the widening and strengthening of existing public road network in case the same is proposed to be used for the Project. No road movement should be allowed on existing village road network without appropriately increasing the carrying capacity of such roads. | Transportation of the lead & zinc ore is being done by road which is passing through Highways. |
| 14. | The illumination and sound at night at project sites disturb the villages in respect of both human and animal population. Consequent sleeping disorders and stress may affect the health in the villages located close to mining operations. Habitations have a right for darkness and minimal noise levels at night. PPs must ensure that the biological clock of the villages is not disturbed; by orienting the floodlights/ masks away from the villagers and keeping the noise levels well within the prescribed limits for day light/night hours. | Ensured the biological clock of the villagers by orienting the floodlights/ masks away from the villagers and keeping the noise levels well within the prescribed limit for day and night. |
| 15. | Main haulage road in the mine should be provided with permanent water sprinklers and other roads should be regularly wetted with water tankers fitted with sprinklers. The material transfer points should invariably be provided with Bag filters and or dry fogging system. In case of Belt-conveyors facilities the system should be fully covered to avoid air borne dust; Use of effective sprinkler system to suppress fugitive dust on haul roads and other transport roads shall be ensured. | Regular water sprinkling is being done on the haul road. |
| 16. | Sufficient number of Gullies to be provided for better management of water. Regular Monitoring of pH shall be included in the monitoring plan and report shall be submitted to the Ministry of Environment, Forest and Climate Change and its Regional Office on six monthly bases. | Regular pH of mine water is being monitored.<br>Report enclosed annexure-**VI** |
| 17. | There shall be planning, developing and implementing facility of rainwater harvesting measures on long term basis and implementation of conservation measures to augment ground water resources in the area in consultation with Central Ground Water Board. | Rainwater harvesting is being done and water recharge structure made in consultation with CGWA. |
| 18. | The Project Proponent has to take care of gullies formed on slopes. Dump mass should be consolidated with proper | All the waste used in backfilling purpose. |

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| | filling/leveling with the help of Dozer/compactors. | |
| 19. | The reclamation at waste dump sites shall be ecologically sustainable. Scientific reclamation shall be followed. The local species may be encouraged and species are so chosen that the slope, bottom of the dumps and top of the dumps are able to sustain these species. The aspect of the dump is also a factor which regulates some climatic parameters and allows only species adapted to that micro climate. | All the mine waste reused for backfilling of void stop. |
| 20. | The top soil, if any, shall temporarily be stored at earmarked site(s) only and it should not be kept unutilized for long. The topsoil shall be used for land reclamation and plantation. The over burden (OB) generated during the mining operations shall be stacked at earmarked dump site(s) only and it should not be kept active for a long period of time. The maximum height of the dumps shall not exceed 8m and width 20 m and overall slope of the dumps shall be maintained to 45°. The OB dumps should be scientifically vegetated with suitable native species to prevent erosion and surface runoff. In critical areas, use of geo textiles shall be undertaken for stabilization of the dump. The entire excavated area shall be backfilled and afforested. Monitoring and management of rehabilitated areas should continue until the vegetation becomes self-sustaining. Compliance status shall be submitted to the Ministry of Environment, Forest and Climate Change and its Regional Office on six monthly basis. | The top soil stored at earmark location of 9000 CuM soil in 645 Sq M and developed a beautiful garden on it.<br>All the waste utilized in the mine void refilling. No such OB Dump. |
| 21. | Catch drains and siltation ponds of appropriate size shall be constructed around the mine working, mineral and OB dumps to prevent run off of water and flow of sediments directly into the river and other water bodies. The water so collected should be utilized for watering the mine area, roads, Green belt development etc. The drains shall be regularly desilted Particularly after monsoon and maintained properly. The drains, settling tanks and check dams of appropriate size, gradient and length shall be constructed both around the mine pit and over burden dumps to prevent run off of water and flow of 'sediments directly into the river and other Water bodies and sump capacity should be designed keeping 50% safety margin over and above peak sudden rainfall (based on 50 years data) and maximum discharge in the area adjoining the mine site. Sump capacity should also provide adequate retention period to allow proper settling of silt Material. Sedimentation pits shall be constructed at the corners of the garland drains and desilted at regular intervals. | Catch drains and siltation ponds constructed to collect and prevent run off water and flow of sediments directly into the river and other water bodies. Water so collected used for dust suppression in mine area haul roads, green belt development, recharge etc . The drain and settling pond are being regularly de-silted and maintained properly. |
| 22. | Plantation shall be raised in a 7.5m wide green belt in the safety zone around the mining lease, backfilled and reclaimed area, around water body, along the roads etc. by planting the native species in consultation with the local DFO/Agriculture Department and as per CPCB Guidelines. The density of the | Plantation has been raised around boundary of acquired area along the road etc. and included the native species. More than 33% Greenbelt has been developed in |

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| | trees should be around 2500 plants per ha. Greenbelt shall be developed all along the mine lease area in a phased manner and shall be completed within first five years. | the mine acquired area. Till date 40600 no's saplings planted in 16.8 Ha within lease area and 58000 saplings planted outside lease area. |
| 23. | Project Proponent shall follow the mitigation measures provided in Office Memorandum No. Z-11013/57/2014-IA.II (M), dated 29th October, 2014, titled "Impact of mining activities on Habitations-Issues related to the mining Projects wherein Habitations and villages are the part of mine lease areas or Habitations and villages are surrounded by the mine lease area", if any, applicable to the project. | Being ensured |
| 24. | The Project Proponent shall make necessary alternative arrangements, where required, in consultation with the State Government to provide alternate areas for livestock grazing, if any. In this context, Project Proponent should implement the directions of the Hon'ble Supreme Court with regard to acquiring grazing land. The sparse trees on such grazing ground, which provide mid-day shelter from the scorching sun, should be scrupulously guarded against felling and plantation of such trees should be promoted. | Ensured |
| 25. | The project proponent shall take all precautionary measures during mining operation for conservation and protection of endangered fauna, if any, spotted in the study area. Action plan for conservation of flora and fauna shall be prepared and implemented in consultation with the State Forest and Wildlife Department, A copy of action plan shall be submitted to the Ministry of Environment, Forest and Climate Change and its Regional Office. | A nursery has been developed within mine area for rare plant's species and other medicinal plants. Same being included in yearly plantation program to improve their existence. |
| 26. | As per the Company Act, the CSR cost should be 2 % of average net profit of last three years. Hence CSR expenses should be as per the Company Act/Rule for the Socio Economic Development of the neighborhood Habitats which could be planned and ,executed by the Project Proponent more systematically based on the 'Need based door to door survey' by established Social Institutes/Workers. The report shall be submitted to the Ministry of Environment, Forest and Climate Change and its Regional Office on six monthly bases. | The baseline needs assessment Survey done. |
| 27. | Provision shall be made for the housing of construction labor within the site with all necessary infrastructure and facilities such as Mel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, crèche etc. The housing may be in the form of temporary structures to be removed After the completion of the project. | The facilities are provided like Canteen, Toilets, STP, and safe drinking water and a permanent Doctor for their health care and crèche etc. |
| 28. | Measures should be taken for control of noise levels below 85 dBA in the work environment. Workers engaged in operations of HEMM, etc. should be provided with ear plugs / muffs. | Regular monitoring of the noise in work environment is being carried out and workers engaged in operations of HEMM are being ensured with ear muffs. |

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| 29. | Industrial waste water (workshop and waste water from the mine) should be properly collected, treated so as to conform to the standards prescribed under GSR 422 (E) dated 19th May, 1993 and 31st December, 1993 or as amended from time to time. Oil and grease trap should be installed before discharge of workshop effluents. | Oil and grease trap have been installed at vehicle washing area and clean water reuse for vehicle washing. Mine water reused for drilling and dust suppression, CRF Plant. Zero discharge Maintained. |
| 30. | Personnel working in dusty areas should wear protective respiratory devices and they should also be provided with adequate training and information on safety and health aspects. | Job specific PPE are mandatory for all workers and regular training being given on safety and health aspect. |
| 31. | A separate environmental management cell with suitable qualified personnel should be set-up under the control of a Senior Executive, who will report directly to the Head of the Organization. | A separate environmental management department is in place under control of SBU Director. |
| 32. | The funds earmarked for environmental protection measures should be kept in separate account and should not be diverted for other purpose. Year wise expenditure should be reported to the Ministry and its Regional Office. | The funds earmarked for environmental protection measures and kept in separate account. The expenditure from October 2020 to March 2021 has been incurred Rs 54.38 Lacs to implement the Environmental Management Plan. |
| 33. | The project authorities should inform to the Regional Office regarding date of financial closures and final approval of the project by the concerned authorities and the date of start of land development work. | No additional land is required for proposed expansion. |
| 34. | The project proponent shall submit six monthly reports on the status of the implementation of the stipulated environmental safeguards to the Ministry of Environment, Forest and Climate Change, its Regional Office, Central Pollution Control Board and State Pollution Control Board. | Being Complied |
| 35. | The Regional Office of this Ministry shall monitor compliance of the stipulated conditions. The project authorities should extend full cooperation to the officer (s) of the Regional Office by furnishing the requisite data / information / monitoring reports. | The project will extend full cooperation to the officer (s) of the Regional Office by furnishing the requisite data / information / monitoring reports. |
| 36. | A copy of clearance letter will be marked to concerned Panchayat / local NGO, if any, from whom suggestion / representation has been received while processing them proposal. | Being Complied |
| 37. | State Pollution Control Board should display a copy of the clearance letter at the Regional office, District Industry Centre and Collector's office/Tehsildar's Office for 30 days. | Complied |
| 38. | The project authorities should advertise at least in two local newspapers widely circulated, one of which shall be in the vernacular language of the locality concerned, within 7 days of the issue of the clearance letter Informing that the project has been accorded environmental clearance and a copy of | Complied |

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| | the clearance letter is available with the State Pollution Control Board and also at web site of the Ministry of Environment, Forest and Climate Change at www.environmentclearance.nic.inand a copy of the same should be forwarded to the Regional Office. | |
| 14. | The Ministry or any other competent authority may alter/modify the above conditions or stipulate any further condition in the interest of environment protection. | Assured to comply |
| 15. | Concealing factual data or submission of false/fabricated data and failure to comply with any of the conditions mentioned above may result in withdrawal of this clearance and attract action under the Provisions of the Environment (Protection) Act, 1986. | Assured to Comply |
| 16. | The above conditions will be enforced inter-alia, under the provisions of the Water (Prevention & Control of Pollution) Act, 1974, the Air (Prevention & Control of Pollution) Act, 1981, the Environment (Protection) Act, 1986 and the Public Liability Insurance Act, 1991 along with their amendments and rules made there under and also any other orders passed by the Hon'ble Supreme Court of India/ High Court of Rajasthan and any other Court of Law relating to the subject matter. | Assured to Comply |
| 17. | Any appeal against this environmental clearance shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010. | Assured to Comply |

Sensitivity: Internal (C3)

# Environmental Monitoring and Evaluation Studies at Kayad Mines, of Hindustan Zinc limited

Sponsored by
Kayad Mines, Hindustan Zinc Ltd.

CSIR-National Environmental Engineering Research Institute

Nehru Marg, Nagpur - 440020

February 2021

# *FOREWORD*

*Mining activities which involves extraction of minerals from natural deposits leads to natural imbalances, which may adversely affect the surrounding environment. The key environmental impacts of mining includes contamination of surface and groundwater and soil, loss of biodiversity, adverse impacts on vegetation and human health etc. Several studies have established that mining operations may contaminate the environment in vicinity through dispersion, deposition and leaching of contaminants (particularly heavy metals) from weathering of the mineral deposits and overburden dumps and due to other mining operations. Keeping in in view the possibility of contamination of surrounding environment due to mining operations, Hindustan Zinc Limited (HZL) engaged CSIR-National Environmental Engineering Research Institute (CSIR-NEERI), Nagpur to study the impact of mining operations on water bodies, soil, vegetation, agricultural crops, invertebrates and aquatic fauna in the surrounding area of Kayad Zinc Mines, Ajmer Rajasthan.*

*Extensive field visits for reconnaissance survey and sampling were conducted and samples of soil, surface and ground water, plants & invertebrates were collected and analysed in the laboratory following standard methods and strict QA/QC protocols. Clear trend of distribution of most of the metals w.r.t. upstream and downstream of the mining area and also in comparison with control location was not observed. Levels of several metals were even relatively higher in control location indicating presence due to natural origin and ruling out the impact due to mining activities. Faunal diversity is minimal as the lease area is guarded and moreover activities like grazing of domestic animals is prohibited in the mine vicinity. In order to study the impact on nearby vegetation and crops, detailed studies including Stomatal Studies (SS), Importance Value Index (IVI) Air pollution Tolerance Index (APTI) Measurement etc. have been carried out, findings of which further established that there are no impacts of mining operations on surrounding vegetation and crops. There was no ecologically sensitive flora or fauna observed in the study area. Metals were also monitored in various insects and invertebrates and the concentrations of metals were mostly in the naturally occurring ranges and does not reflects accumulation due to mining activities.*

*The findings of the study have established that there are no adverse impacts on water, soil and vegetation in the surrounding area of Kayad mines due to mining operations. It is recommended that regular environmental monitoring program to be followed and green belt may be developed around the mining area to mitigate any possible impacts in future. The detailed results and findings are presented in this report.*

*The co-operation and assistance rendered by officials of HZL, Kayad Mines during the field visits and in providing the required data and information is gratefully acknowledged.*

*Nagpur* ***(Rakesh Kumar)***
*February 2021* ***Director, NEERI***

# Project Personnel

**Project Staff**

Dr. Manisha Meshram

Ms. Rashmi Dahake

Ms. Ketki Kulkarni

**Hindustan Zinc Limited, Kayad Mines, Rajasthan**

Mr. Mansingh Gehlot

**Project Leader**

Dr. Amit Bansiwal

**Co-Project Leaders**

Dr. Atul N. Vaidya

Dr. Mahendra P. patil

**Project Coordinator**

Dr. Rakesh Kumar

**Director**

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# Chapter 1: Introduction

## 1.1 Preamble

Hindustan Zinc (HZL) is India's largest and world's second largest zinc-lead miner. HZL's operations are broad based and its activities range from exploration, mining and ore processing to smelting and refining of lead, zinc, silver, cadmium, copper and sulphuric acid. Hindustan Zinc's operations comprise five lead-zinc mines, one rock phosphate mine, four hydrometallurgical zinc smelters, two lead smelters, one pyro metallurgical lead-zinc smelter as well as sulphuric acid and captive power plants in northwest India. Total metal production capacity is 834,000 MT of zinc and 201,000 MT of lead. Facilities are located in Rampura Agucha, Chanderiya, Dariba, Kayad and Zawar in the state of Rajasthan, along with zinc-lead processing and refining facilities and a silver refinery at Pantnagar in the state of Uttarakhand. Rampura Agucha (RAM) is world's largest Zn mines & Kayad is an extension of RAM.

## 1.2 Site Description

The underground Lead Zinc Mine is located at village Kayad in Tehsil and District Ajmer of Rajasthan. The deposit lies between latitude N26°31'41.47" to N26°31'37.04", longitude E74°41'30.73" to E74°41'30.45", and is covered by Survey of India Topo sheet no. 45 J/10. The project site is located 9-Km NNE of Ajmer city. The Kayad Lead-Zinc deposit extends over area of 480.45 ha with an estimated ore reserves and resources of 5.5 million tons with grades of 6.9% Zinc and 1.20% Lead as on 1/04/2020. The target production capacity of mine is about 1.20 Mtpa.

Kayad mine is the newest mine of the Company starting its operations in 2012. Kayad has access to the mine through decline. Mining method is blast hole open stopping with mined out stopes backfilled with cemented rock fill.

## 1.3 Scope of the Study

With the view of various possible environmental impacts due to different activities related to mining, at Kayad Mine, HZL engaged CSIR-National Environmental Engineering Research Institute (CSIR-NEERI), Nagpur in January-2019 for carrying out a comprehensive environmental assessment study in and around the mine lease area with respect to following components:

- Study on water bodies (surface and groundwater) in and around mine lease area for heavy metal and other physico-chemical parameters.

- Monitoring of invertebrates and aquatic life (fish) of water bodies including the reservoir located close to the mining lease to assess bio accumulation of heavy metals, if any
- Assessment of Impact of mining activities on soil quality and agriculture crops in the surrounding area with respect to Zinc, Cadmium and lead etc.
- Assessment of Impact of mining activities on growth of vegetation within the lease area and carrying out ecological survey with a perspective to variety of plant species to be grown within the lease area.

## 1.4 Objectives of the Study

The purpose of the study is to assess the vulnerability of the environment to the pollution at Kayad mine of Hindustan Zinc Ltd. due to mining and associated activities.

The major objectives of the project are:

- Site Reconnaissance of surrounding area.
- Assessments on the impact of mining activity on water and ground waters in the nearby areas.
- Assessments on the impact of mining activity on invertebrates
- Assessments on the impact of mining activity on essential nutrient status and soil fertility.
- Assessment of heavy metal mobility in soil-crop plant system.
- Impact of mining activity on the growth and yield of crop plants.

The detailed component wise scope of work as discussed and revised during the course of the study is as follows:

### 1.4.1 Monitoring of water bodies (surface and groundwater) in and around mine lease area for heavy metal and other physico-chemical parameters

i) Collection of water samples from surface water bodies including ponds, lakes, reservoirs, rivers etc. and ground water samples from dug wells and bore wells in and around the mine lease area.

ii) Preservation and transportation of samples to CSIR-NEERI for analysis of various physico-chemical parameters and heavy metals. (Some of the parameters namely pH, Conductivity and TDS will be determined on-site)

iii) The samples will be collected in two seasons namely pre and post monsoon.

iv) The analysis of water samples will be carried out using standard methods including heavy metals analysis using state-of-the-art Inductively Coupled Plasma Mass Spectrometer (ICPMS).

v) Determination of correlation between various water quality parameters and heavy metals and with other components.

**1.4.2 Monitoring of invertebrates and aquatic life (fish) of water bodies including the reservoir located close to the mining lease to assess bio accumulation of heavy metals, if any**

i) Inventory of basic biodiversity to understand invertebrate species present in and around mine lease area.

ii) Collection of samples of invertebrates (earthworms, insects etc.) and fish samples from nearby ponds/lakes and reservoir and other locations in and around the lease area.

iii) Preservation and transportation of invertebrate samples to CSIR-NEERI for analysis of heavy metals including Zn, Pb, Cd, Ni. Cr, Cu etc.

iv) Assessment of Impact of mining activity on bio-accumulation of heavy metals in invertebrates and fishes

**1.4.3 Assessment of Impact of mining activities on soil quality and agriculture crops in the surrounding area with respect to Zinc, Cadmium and lead etc.**

i) Basic biodiversity inventory to understand plant species present in and around mine lease area.

ii) Collection and analysis of soil samples in and around lease area from nearby fields to assess the levels of heavy metals in soils

iii) Collection of samples of crops, plants, vegetables and fruits grown around mine lease area to understand the levels of heavy metals

iv) Assessment of Impact of mining activity on accumulation of heavy metals in plants and plant products

**1.4.4 Assessment of Impact of mining activities on growth of vegetation within the lease area and carrying out ecological survey with a perspective to variety of plant species to be grown within the lease area.**

i) Survey of the local flora to assess the basic floral biodiversity of the area

ii) Conducting ecological survey on the plant species to evaluate their growth in terms of stunted, deformed and seed viability.

iii) Assessments on the impact of mining activity on essential nutrient status and soil fertility

iv) Assessment of heavy metal mobility in soil-crop plant system

v) Assessment of Impact of mining activity on the growth and yield of crop plants

vi) Selection of different plant species for re-vegetation with effective reclamation potential

## 1.5 Methodology

Considering the above objectives and scope of work, CSIR-NEERI Nagpur undertook field visits for reconnaissance survey and sampling simultaneously for the four different components of the study for which two major field visits were undertaken to the Kayad mines. First field visit was carried out in February-2019 and the second visit was carried out in the month of November-2019 to collect samples of pre and post monsoon seasons respectively. Samples of soil, surface and ground water, plants & invertebrates were collected during both the visits. Collection of all the samples were conducted within 5 Km radius of the Kayad mines and from one control location located about 15 km upstream of mine.

These samples were preserved and brought to the labs and were analysed for various physico-chemical parameters as well as for heavy metals. Considering the presence of trace metals as primary constituents of concern major emphasis was given to analysis of heavy metals in these samples. All the above-mentioned components of the study have also been discussed in details in individual chapters in the report.

# Chapter 2: Monitoring of Water Bodies (Surface and Groundwater) in and around Mine Lease Area for Heavy Metal and other Physico-Chemical Parameters

## 2.1 Background

Mining projects vary according to the type of metals or materials to be extracted from the earth. The majority of mining projects involve the extraction of ore deposits such as copper, nickel, cobalt, gold, silver, lead, zinc, molybdenum, and platinum. Many works have shown that contaminants from mine wastes and tailings contribute to increased volume of heavy metals in the ecosystem. Heavy metal effluents from the weathering of the mineral deposits may have adverse consequences on soil and water quality due to soil–water interaction. Keeping in in view the possibility of contamination of surface and ground water by mining activities, the present study was undertaken to study the impact on quality of water in the nearby areas of mines.

## 2.2 Methodology

### 2.2.1 Sampling Details

Water quality analysis was majorly divided into two sections. In the first section the physico-chemical water quality parameters namely pH, conductivity, TDS, alkalinity, hardness etc. were determined using various standard procedures. Wherever possible, pH and conductivity were determined in the field immediately after collection of water sample. Second section is related to one of the important parameters namely metals which are of prime consideration in the present study. The water samples were collected in clean unused polypropylene bottles and were properly coded according to the location. Two sets of samples were collected from same location, one set of bottles were collected for the analysis of basic physico-chemical parameters and another set was spiked with acid for the preservation of samples for metals analysis. In order to study the seasonal trends and to study the possibility of leaching during rains and runoffs, the pre and post monsoon samples were collected from the same sample locations. All the bottles were sealed numbered and stored in clean, cool container. All precautions were taken to avoid any contamination, spillage and mishandling. The coding and other detail of the samples for both the batches is same and is given in **Table 2.1**.

**Table 2.1: Sampling Details for Water Samples**

| Sample Code | Location Details | Latitude | Longitude | Source type | Approximate depth (ft) |
|---|---|---|---|---|---|
| **KY-01** | Hotel Sujan Palace, Pushkar Bypass Jagdamba Dharam Kanta | 26°32'28.334" | 74°39'13.254" | Bore well | 350 |
| **KY-02** | Shivshankar Farm house (**control location**) | 26°35'31.475" | 74°41'13.120" | Bore well | 320 |
| **KY-03** | Satishji Kasad Farm | 26°30'40.974" | 74°41'13.120" | Bore well | 480 |
| **KY-04** | Farm adjacent to Fulsagar lake | 26°52'92.365" | 74°66'98.706" | Tube well | 640 |
| **KY-05** | Farm Behind MDS University Auditorium Building, | 26°50'74.392" | 74°68'33.929" | Open dug well | 90 |
| **KY-06** | Mr. Sadar Khan, Near Telephone Exchange, Jaipur Road, Ghogra Village | 26°50'59.626" | 74°69'71.745" | Bore well | 800 |
| **KY-07** | Devdatta Farm Kayampura Road | 26°55'55.337" | 74°71'93.473" | Hand pump | - |
| **KY-08** | Bhawanrlal Gokulji Yadav Aahir, Farm Gangawana to Ladpura Road | 26°52'04.961" | 74°73'08.060" | Open dug well | 150 |
| **KY-09** | Open Dug Well Near, Vishramsthali (north side) | 26°52'78.716" | 74°70'28.282" | Open Dug Well | 120 |
| **KY-10** | Farm of Kamruddin Medhri Mirzalli Gagwana Road, Behind Zine Mine | 26°32'06.842" | 74°41'51.757" | Open Dug Well | 95 |

## 2.2.2 Analysis of samples

Brief details of standard methods of analysis used for various parameters are summarised in **Table 2.2**.

**Table 2.2: Summary of Methods of Analysis of Water Samples**

| Parameter | Standard Method Used in present study | Brief Details |
|---|---|---|
| **pH** | APHA 23rd Edition: 4500 H+B: 2017 | pH electrode with digital reading meter |
| **Conductivity** | APHA 23rd Edition: 2510 B: 2017 | Conductivity electrode with digital reading meter |
| **Total Dissolved Solids (TDS)** | APHA 23rd Edition: 2540 C: 2017 | Gravimetric determination through heating at 110°C |
| **Alkalinity** | APHA 23rd Edition: 2320 B : 2017 | Titrimetric |
| **Hardness** | APHA 23rd Edition: 2340 C: 2017 | Titrimetric |
| **Fluorides** | APHA-23rd Edition: 4500-F-C: 2017 | Ion Selective Electrode with specific ion meter |
| **Metals** | ISO 17294-2:2016 | Microwave digestion followed by analysis using Inductively Coupled Plasma Mass Spectrometer (ICPMS) |

**Digestion Procedure for total Metal Analysis:**

Digestion of the acid preserved and unfiltered samples were done for analysis of total heavy metal concentrations. The digestion of the samples for total metals analysis was done by microwave acid digestion method. A representative aqueous sample is extracted with combination of concentrated nitric acid and concentrated hydrochloric acid, using microwave heating with a suitable laboratory microwave unit. The sample and acid(s) are placed in a PTFA microwave vessels. The vessel is sealed and heated in the microwave unit for a specified period of time. After cooling, the vessel contents are filtered, centrifuged, or allowed to settle and then diluted to volume and analysed by ICPMS. Briefly, 15 ml of the sample was taken and 6 ml Nitric acid and 2 ml Hydrochloric acid was added. The program for complete acid digestion of sample were optimized and found to be 40 % power rating for 10 min, 80 % power rating for 10 min and 100 % power rating for 5 min. The solution was stored and diluted for further analysis. All the samples were digested and analysed in triplicates.

### 2.2.3 Quality Assessment and Quality Control

Comprehensive quality assurance and control checks were also performed by determining recoveries for digestion and analysis methods. The results of recoveries and other statistical parameters are presented in Annexure I. The results of QA & QC exercise have established that both sample preparation (digestion) and analytical protocols are well optimised with recoveries in the range of 91-130 % in low range and 92-106 % in high spike range. These results also revealed that standard

deviation varied between 0.8 to 3.3 and 0.6 to 2.47 in low and high spike range respectively. All these data confirm that the performance data for both sample preparation and analysis are well below the acceptable ranges

## 2.3 Summary of Observations for Water Samples

The chemical pollutants in water are primarily related with environment around it and the chances of contamination is more near mines. The chemical contaminants may include dissolved ions and solids, various metals and non-metals like fluorides etc. Considering the presence of trace metals as primary constituents of concern in the overburden and various mining activities, major emphasis was given analysis of heavy metals in these samples. Total 20 water samples were collected and analysed during pre and post monsoon seasons for water quality parameters namely pH, conductivity, TDS, Fluorides, Alkalinity & Hardness. Detailed investigations were also carried out to analyse various trace metals in the water samples. The results of physico-chemical water quality parameters are presented in **Table 2.3 - 2.6** and **Figure 2.1** & **2.2** and salient findings are summarised below:

**pH:** pH of water for all the samples were found to be within the permissible range as per IS 10500 for drinking water and WHO according to which the pH of water should be between 6.5 to 8.5. pH of most of the water samples were observed to be near neutral. pH range for pre-monsoon samples were found to be between 7.2- 7.6 and for post-monsoon it was between 7- 7.5.

**Conductivity and TDS:** Conductivity is directly related to the concentration of dissolved ions in the water. Conductivity for pre-monsoon samples were observed to be in the range of 600- 8000 µS/cm and for post-monsoon it was observed to be 625- 7450 µS/cm. Observed conductivity for both seasons were in similar range indicating marginal dilution of water sources except for sample KY-09 which showed the drastic decrease in the conductivity for the post-monsoon period. According to WHO, permissible limit for TDS is 2000 mg/l. Out of 10 samples, 4 samples showed the TDS above permissible limit for both the seasons. For pre-monsoon set, KY-06 was observed to be near the permissible limit but for post-monsoon period it exceeded the permissible limits. Similarly, for KY-09 decrease in TDS was observed for post-monsoon sample in accordance with conductivity trends. KY-07, KY-08, KY-10 exceeded the permissible limits for both the seasons. High TDS is observed in most of the samples indicating high dissolution of geogenic ions in the region.

**Fluorides:** Permissible limit for Fluorides in water is 1-1.5 ppm. Most of the pre-monsoon samples showed concentration of fluorides within permissible range except for few locations. For post-monsoon samples concentration of fluorides was found to decrease. Relatively high fluorides were observed in sample KY-01 which

exceeded the permissible limits for both the seasons. The post-monsoon concentrations were observed to be slightly diluted.

**Alkalinity and Hardness:** Most of the samples from both pre and post monsoon seasons showed slightly higher values of alkalinity and hardness in accordance with TDS data. Samples KY-01 & KY-07 showed to exceed the threshold limit of 600 mg/l in both the seasons. Other samples found to be within the desired limit. Four samples from the pre-monsoon sample showed to cross the permissible limit for hardness, for post-monsoon season, hardness was found to increase during which 7 samples exceeded the permissible limits.

**Heavy Metals in Water:** The levels of various metals in water sources are important indicators of impact of mining activities in the vicinity. Several metals were monitored in water samples during pre and post monsoon seasons. Concentrations of most of the metals were either below detection limits (BDL) or in traces (sub ppm levels). **Arsenic** was observed in traces in both the seasons. Concentration of As was found to be relatively higher during post-monsoon period as compared to pre-monsoon period. For both the seasons most of the samples showed the concentrations within the permissible limits as per Indian drinking water standards (IS 10500, 2012). **Silver & Cadmium** concentrations were found to be below detection limit for both the seasons. The sample from location KY-07 from post-monsoon batch showed the presence of traces of Ag & Cd otherwise he levels of Ag and Cd and in samples from other locations were below the detection limits for both the seasons. **Cobalt** concentrations in both the pre-monsoon & post-monsoon seasons at all the locations were observed in traces or below detection limits. **Chromium** was also observed in traces in almost all the samples of pre-monsoon batch. The concentration of Cr was found to be higher in post-monsoon batch as compared to pre-monsoon batch. **Copper** in some of the samples from pre-monsoon season showed to exceed the acceptable limit as per IS 10500. Samples from KY-06 & KY-07 locations from the post-monsoon batch showed traces of Cu. **Manganese** levels in samples from both the seasons were observed to be nearly in the same range. Two samples from pre-monsoon set showed slightly elevated concentrations as compared prescribed limits as per drinking water standards. **Lead** is observed in trace levels in both the seasons and were in same levels. Only one sample from KY-06 location from the post-monsoon batch showed to exceed the concentration as compared prescribed limits as per drinking water standards. **Zinc** is important indicator considering the mining activities. The pre-monsoon batch showed relatively higher concentrations as compared to post monsoon season. Zn concentrations in all the samples were within prescribed limits as compared to drinking water standards.

Clear trend of distribution of most of the metals w.r.t. upstream and downstream of the mining area and also in comparison with control location was not observed. Levels of several metals were even relatively higher in control location indicating presence due to natural origin and ruling out the impact due to mining activities.

**Table 2.3 & 2.4** shows pre-monsoon and post-monsoon physico-chemical parameters data.

**Table 2.3: Physcio-chemical Parameters for Pre-monsoon Set**

| Sample Code | pH | Conductivity (µS)/cm | TDS (ppm) | Fluoride (ppm) | Alkalinity (mg/L) | Hardness (mg/L) |
|---|---|---|---|---|---|---|
| **KY-01** | 7.691 | 1682 | 839 | **4.40** | **820** | 160 |
| KY-02 | 7.315 | 642 | 321 | 0.74 | 420 | 290 |
| **KY-03** | 7.469 | 1915 | 968 | 1.20 | 520 | 480 |
| **KY-04** | 7.425 | 2600 | 1306 | 1.70 | 480 | 440 |
| **KY-05** | 7.341 | 1627 | 814 | 1.20 | 484 | 300 |
| **KY-06** | 6.953 | 3900 | 1954 | 1.90 | 300 | 520 |
| **KY-07** | 7.345 | 6280 | **3150** | 2.10 | **730** | **750** |
| **KY-08** | 7.213 | 4820 | **2430** | 0.01 | 460 | **1300** |
| **KY-09** | 7.347 | 8040 | **4000** | 2.30 | 590 | **740** |
| **KY-10** | 7.418 | 8000 | **4020** | 0.95 | 540 | **1200** |

**Table 2.4: Physcio-chemical Parameters for Post-monsoon Set**

| Sample Code | pH | Conductivity (µS)/cm | TDS (ppm) | Fluoride (ppm) | Alkalinity (mg/L) | Hardness (mg/L) |
|---|---|---|---|---|---|---|
| KY-01 | 7.588 | 1592 | 799 | 3.30 | 848 | 7.2 |
| KY-02 | 7.276 | 625 | 313 | 0.46 | 320 | 216 |
| KY-03 | 7.27 | 1527 | 765 | 0.65 | 424 | 478.8 |
| KY-04 | 7.171 | 3620 | 1833 | 0.98 | 384 | 1076.4 |
| KY-05 | 7.293 | 3100 | 1610 | 1.10 | 220 | 640.8 |
| KY-06 | 7.006 | 4910 | 2480 | 1.10 | 344 | 1702.8 |
| KY-07 | 7.491 | 6330 | 3170 | 1.30 | 976 | 1108.8 |
| KY-08 | 7.047 | 5180 | 2610 | 0.10 | 480 | 1548 |
| KY-09 | 7.59 | 1592 | 797 | 1.20 | 460 | 172.8 |
| KY-10 | 7.218 | 7450 | 3770 | 0.66 | 544 | 2430 |

**Table 2.5** & **2.6** shows pre-monsoon and post-monsoon Heavy metals data respectively.

**Table 2.5: Heavy Metals Data for Pre-monsoon Set**

| Elements | As | Ag | Cd | Co | Cr | Cu | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| Permissible limits as per BIS 10500: | 0.050 | 0.100 | 0.005 | - | 0.100 | 1.50 | 0.300 | 0.020 | 0.010 | 5.000 |
| Samples | Concentration: ppm | | | | | | | | | |
| KY-01 | 0.001 | BDL | BDL | BDL | 0.002 | 0.091 | 0.004 | 0.005 | 0.001 | 0.058 |
| KY-02 | BDL | BDL | BDL | 0.001 | 0.007 | 0.014 | 0.008 | 0.042 | 0.002 | 0.063 |
| KY-03 | 0.006 | BDL | BDL | 0.001 | 0.004 | 0.050 | 0.004 | 0.030 | 0.002 | 0.059 |
| KY-04 | 0.007 | BDL | BDL | 0.001 | 0.002 | 0.083 | 0.004 | 0.019 | 0.001 | 0.042 |
| KY-05 | 0.005 | BDL | BDL | 0.001 | 0.003 | 0.051 | 0.013 | 0.042 | 0.003 | 0.055 |
| KY-06 | 0.017 | BDL | BDL | 0.001 | 0.008 | 0.063 | 0.150 | 0.036 | 0.002 | 0.061 |
| KY-07 | 0.024 | BDL | BDL | 0.002 | 0.008 | 0.348 | 0.059 | 0.025 | 0.008 | 3.145 |
| KY-08 | 0.032 | BDL | BDL | 0.003 | 0.007 | 0.094 | 0.056 | 0.034 | 0.002 | 0.052 |
| KY-09 | 0.029 | BDL | BDL | 0.001 | 0.003 | 0.380 | 0.014 | 0.015 | 0.001 | 0.019 |
| KY-10 | 0.036 | BDL | BDL | 0.002 | 0.003 | 0.254 | 0.256 | 0.025 | 0.001 | 0.018 |

**Table 2.6: Heavy Metals Data for Post-monsoon Set**

| Elements | As | Ag | Cd | Co | Cr | Cu | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| Permissible limits as per BIS 10500: | 0.050 | 0.100 | 0.005 | - | 0.100 | 1.500 | 0.300 | 0.020 | 0.010 | 5.000 |
| Samples | Concentration: ppm | | | | | | | | | |
| KY-01 | 0.010 | BDL | BDL | BDL | 0.011 | BDL | 0.006 | 0.007 | 0.001 | 0.012 |
| KY-02 | 0.005 | BDL | BDL | 0.001 | 0.014 | BDL | 0.007 | 0.013 | 0.002 | 0.015 |
| KY-03 | 0.011 | BDL | BDL | 0.001 | 0.011 | BDL | 0.005 | 0.012 | 0.001 | 0.019 |
| KY-04 | 0.029 | BDL | BDL | 0.001 | 0.012 | BDL | 0.061 | 0.014 | BDL | 0.001 |
| KY-05 | 0.022 | BDL | BDL | 0.001 | 0.015 | BDL | 0.012 | 0.017 | 0.001 | 0.021 |
| KY-06 | 0.037 | BDL | BDL | 0.010 | 0.060 | 0.054 | 0.615 | 0.045 | 0.012 | 0.017 |
| KY-07 | 0.056 | 0.002 | 0.001 | 0.001 | 0.020 | 0.034 | 0.032 | 0.016 | 0.005 | 0.243 |
| KY-08 | 0.054 | BDL | BDL | 0.002 | 0.013 | BDL | 0.041 | 0.025 | 0.001 | 0.010 |
| KY-09 | 0.015 | BDL | BDL | 0.001 | 0.027 | BDL | 0.082 | 0.012 | 0.003 | 0.006 |
| KY-10 | 0.040 | BDL | BDL | 0.001 | 0.007 | BDL | 0.059 | 0.011 | BDL | 0.005 |

Figure **2.1** & **2.2** shows the graphs for the distribution pre-monsoon and post-monsoon Heavy metals data respectively.

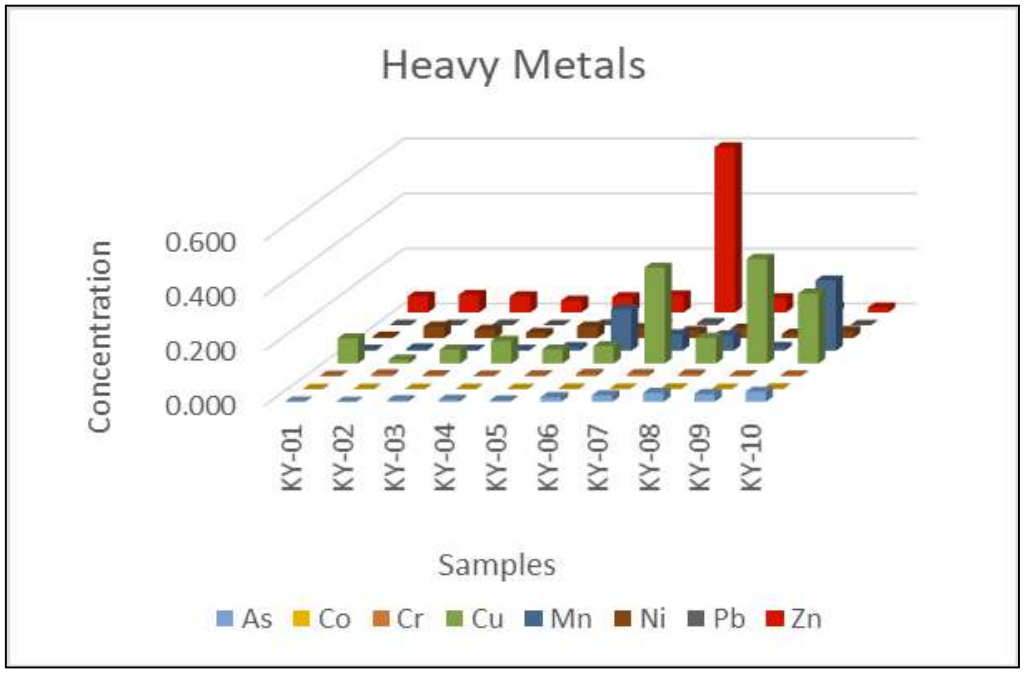



**Figure 2.1: Distribution of Various Metals in Water Samples of various Locations during Pre-monsoon Period**

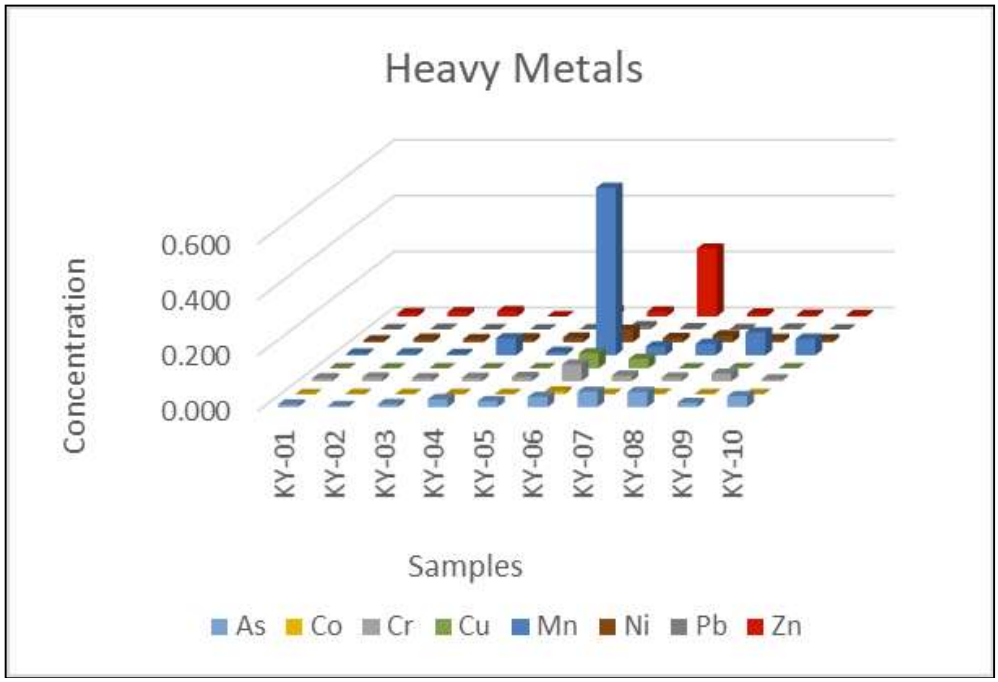



**Figure 2.2: Distribution of Various Metals in Water Samples of various Locations during Post-monsoon Period**

# Chapter 3: Monitoring of Invertebrates and Aquatic Life (Fish) of Water Bodies including the Reservoir Located close to the Mining Lease to Assess Bioaccumulation of Heavy Metals, if any

## 3.1 Background

### 3.1.1 Fauna

The population of fauna, near the study, was found to be low. Faunal diversity is non-existent in the core zone as the zinc mine voids and surrounding area is gated and guarded, moreover activities like grazing of domestic animals is forbidden in the vicinity. Consequently, there is no adverse impact on the fauna existing in the project study area. The area is not the migratory route for any wild animal. There are no rare, threatened and endangered faunal species in the buffer zone. The avifauna includes Common myna, Pied crested cuckoo, Pigeon, Crow, Crow pheasant, Owl, Hyna etc. Few domestic buffaloes, cows, goat were found grazing in the vicinity of study area **(Table 3.1)**. During the field survey Common Egret was also observed near the study area (**Fig. 3.1**).

The faunal diversity in the study area is minimal, however when the zinc mine voids reach their dust holding capacity, the filled up voids will be rejuvenated following proper methods including plantation programs leading to habitat development for fauna and thereby an increase in faunal diversity.

**Figure 3.1: Common Egret observed near the Ajmer city during the Field Survey by NEERI**

**Table 3.1: Fauna recorded in the Study Area**

| Local Name | English Name | Latin Name |
|---|---|---|
| **Fauna** | | |
| Minki | Wild cat | *Felis catus* |
| Gandura | Boar/Black pig | *Sus scrofa cristatus* |
| Gandhak | Dog | *Canis familiaris* |
| Tillodi | Squirrel | Funambulus pennanti |
| Bhandro | Monkey | *Presbytis entellus* |
| Undro | Rat | *Rattus rattus* |
| Neula | Common mangoose | *Herpestes eduardsii* |
| Chalie | Goat | *Capra aegagrus hircus* |
| Zhoti | Buffalo | *Bubalus bubalis* |
| Gay | Cow | *Bos taurus* |
| **Avifauna** | | |
| Bani | Common myna | *Acridotheres tristis* |
| Chatak | Pied crested cuckoo | *Clammator jacobinus* |
| Deulia para | Pigeon | *Anastomus oscitans* |
| Kau | Crow | Corvus microheroes |
| Kumbhatua | Crow pheasant | *Centropus sinensis* |
| *Pecha* | *Owl* | *Athena brama* |
| *Sari* | *Hyna* | *Gracula religiosa* |
| **Amphibians** | | |
| Mendhak | Frog | *Anura* |
| **Lizards** | | |
| Bahurupi | Indian Chameleon | *Chammaeleon zeylanicus* |
| Jhitipiti | House lizard | *Hemidactylus flaviriridis* |

## 3.2 Methodology for Assessment of Accumulation of Heavy Metals in Invertebrates

### 3.2.1 Sampling Details

Selected species like ants, black carpenter, frogs, grass buds were collected from the three different sampling locations near mines. All these species were brought in the 50ml sample bottles. Details of the samples are given in **Table 3.2**

**Table 3.2: Sample Details**

| Sampling Location | Location Details | Type of Sample |
|---|---|---|
| **KY 02** | Shivshankar Farm house (**control location**) | Grass buds, Black Carpenter, Ant |
| **KY 03** | Satishji Kasad Farm | Larvae |
| **KY05** | Farm behind MDS University Auditorium Building | Frog, Spider, Black Carpenter Ant |

### 3.2.2 Characterization of samples: Parameters and Methods used

Heavy Metals Analysis in invertebrate samples: US EPA method was used for preparation of samples using Microwave Digestion. Sample was dried weighed and transferred to microwave digestion vessel, and according to weight of particular sample, mixture of $HNO_3$ and $H_2O_2$ was added and this mixture was digested with inbuilt program. Sample obtain was diluted, filtered and was analyzed on ICP-MS for various heavy metals.

## 3.3 Observations for Samples

**Table 3.3: Heavy Metals Present in Invertebrates**

| Samples | KY-02 (Control Location) | | KY-03 | KY-05 | | |
|---|---|---|---|---|---|---|
| | Grass Bug Small | Black Carpenter Ant | Larvae | Frog | Grass Bug Small | Black Carpenter Ants |
| | Concentration in mg/kg | | | | | |
| **As** | 0.030 | 0.208 | 0.013 | 0.005 | 0.129 | 0.240 |
| **Ag** | BDL | 0.002 | BDL | 0.001 | BDL | 0.018 |
| **B** | 4.285 | 3.200 | 1.500 | 0.095 | 4.079 | 4.891 |
| **Ba** | 1.784 | BDL | 0.690 | 0.595 | 1.904 | 11.902 |
| **Be** | 0.001 | BDL | 0.001 | BDL | 0.005 | 0.023 |
| **Bi** | 0.145 | 0.382 | 0.056 | 0.001 | 0.300 | 0.107 |
| **Cd** | 0.023 | BDL | 0.005 | 0.001 | 0.010 | 0.129 |
| **Cu** | BDL | BDL | BDL | BDL | BDL | 0.000 |
| **Cr** | BDL | BDL | BDL | BDL | BDL | 47.767 |
| **Mo** | BDL | BDL | BDL | BDL | BDL | BDL |
| **Ni** | 0.062 | BDL | 0.115 | 0.019 | 5.183 | 22.334 |
| **Pb** | 0.294 | 0.025 | 0.254 | 0.026 | 1.236 | 1.974 |
| **Se** | 0.097 | 0.047 | 0.115 | 0.055 | 0.123 | 0.245 |
| **V** | 0.041 | 0.002 | 0.026 | 0.008 | 0.236 | 1.100 |
| **Zn** | 50.260 | 26.977 | 13.763 | 2.290 | 40.394 | 75.363 |

## 3.4 Conclusions for Invertebrates

- Faunal diversity is minimal as the lease area is guarded and moreover activities like grazing of domestic animals is prohibited in the mine vicinity.
- There is no ecologically sensitive flora or fauna in the study area.
- **Presence of metals in invertebrates:** The metals observed in different samples were mostly in the naturally occurring ranges and does not reflects accumulation due to mining activities. The control site also showed concentrations in similar ranges as that of other locations indicating that mining activities has not impacted the invertebrates.

# Chapter 4: Assessment of Impact of Mining Activities on Soil Quality and Agriculture Crops in the Surrounding Area with respect to Zinc, Cadmium and Lead etc.

## 4.1 Background

It has been extensively reported that mining and mineral processing including transportation of ores and finished products may impact the surrounding area, particularly through leaching of heavy metals in surrounding soil and water bodies. The leached heavy metals can transport in the soil through pore-water advection, convection and solute diffusion/dispersion and can contaminate both the land and the groundwater. Mine waste-materials rejects or traces due to mining activity can be found in the vicinity of the mine and sometimes may reach the far away locations from the source. Soil quality and metal contents can be greatly altered in the sites near mines, leading to plants growth and community changes in the area.

Most of the plants have a low concentration tolerance for metals in the soil, but sensitivity differs among species. Grass diversity and total coverage is less affected by high contaminant concentration than forbs and shrubs. Established plants cannot move away from perturbations, and will eventually die if their habitat is contaminated by heavy metals or metalloids at a concentration that is too elevated for their physiology. Agricultural activities near a mining project may also be affected leading to accumulation of metals in crops. Most crops can grow on weakly contaminated sites, but yield is generally lower than it would have been in regular growing conditions. Plants also tend to accumulate heavy metals in their aerian organs, possibly leading to human intake through fruits and vegetables. Regular consumption of contaminated crops might lead to health problems caused by long-term metal exposure. There is also a possibility of fine dust getting air born during handling, transportation, and storage especially during dry seasons. The air-born dust can get carried to nearby areas and may get deposited on the soil surface as well as on crops and vegetation existing in the surrounding areas.

Ore and mineral processing activities are not undertaken at Kayad site and ore is only transported to Rampura Agucha facility. There may only be possibility of impacts due to excavation and transportation activities for which present studies were undertaken to assess the impact of mining activities on the soil and crops/vegetation in the areas surrounding the Kayad Mine.

## 4.2 Methodology

### 4.2.1 Sampling Details

A site reconnaissance was carried out in an area of about 5 km radius from the Kayad mine to understand the land-use as well as prevailing agriculture activities around the mine area. Based on the site reconnaissance, appropriate sampling locations were identified for collection of soil and crop samples. The two sets of sampling were carried out to cover both Kharif and Rabbi crops. Soil and crop samples were also collected from Control areas, from a distance of about 10 km of upstream from the Kayad Mine, for comparing the soil and crop quality. The soil and crop samples collected during the field studies were carried to CSIR-NEERI, Nagpur for analysis. Considering the presence of trace metals as primary constituents of concern, major emphasis was given analysis of heavy metals in these samples. The detailed methodology of various soil analysis parameters are presented in the following sections:

**Sampling of Soil Samples:** - The samples were collected in cleaned zip pouched of 500-1000 g capacity from the same locations where water samples were collected. At least five soil samples from each location were collected and were homogenously mixed in laboratory to obtain representative sample of each location. For analysis of heavy metals in the soil, soil samples were oven dried and grinded to lower size.

**Sampling of Crop Samples:** - Different types of crops from same locations were cut up to certain level. These crops parts were dried in the sunlight and was packed in zip lock pouches and brought to the lab for analysis. In order to interpret the seasonal effects, the post- monsoon soil samples were collected from the same sampling locations from where the pre-monsoon samples were collected. For crops sampling during post-monsoon season, samples were collected from the selected previous location namely KY-03, KY-05 and KY-07 along with control site KY-02.

The details of the samples for both the batches are same and is given in **Table 4.1**.

**Table 4.1: Sampling details for Soil Samples**

| Sample | Details | Latitude | Longitude |
|---|---|---|---|
| **KY-01** | Hotel Sujan Palace, Pushkar Bypass Jagdamba Dharam Kanta | 26°32'28.334" | 74°39'13.254" |
| **KY-02** | Shivshankar Farm house (**control location**) | 26°35'31.475" | 74°41'13.120" |
| **KY-03** | Satishji Kasad Farm | 26°30'40.974" | 74°41'13.120" |
| **KY-04** | Farm adjacent to Fulsagar lake | 26°52'92.365" | 74°66'98.706" |
| **KY-05** | Farm Behind MDS University Auditorium Building | 26°50'74.392" | 74°68'33.929" |
| **KY-06** | Mr. Sadar Khan, Near Telephone Exchange, Jaipur Road, Ghogra Village | 26°50'59.626" | 74°69'71.745" |
| **KY-07** | Devdatta Farm Kayampura Road | 26°55'55.337" | 74°71'93.473" |
| **KY-08** | Bhawanrlal Gokulji Yadav Aahir, Farm Gangawana to Ladpura Road | 26°52'04.961" | 74°73'08.060" |
| **KY-09** | Open Dug Well Near, Vishramsthali (north side) | 26°52'78.716" | 74°70'28.282" |
| **KY-10** | Farm of Kamruddin Medhri Mirzalli Gagwana Road, Behind Zine Mine | 26°32'06.842" | 74°41'51.757" |

**Table 4.2: Sampling details for Plants Samples**

| Sample | Details | Type of Sample/s |
|---|---|---|
| **KY-01** | Hotel Sujan Palace, Pushkar Bypass Jagdamba Dharam Kanta | Brinjal Plant & other vegetables |
| **KY-02** | Shivshankar Farm house (**control location**) | Barley |
| **KY-03** | Satishji Kasad Farm | Wheat |
| **KY-04** | Farm adjacent to Fulsagar lake | Wheat |
| **KY-06** | Mr. Sadar Khan, Near Telephone Exchange, Jaipur Road, Ghogra Village | Barley |
| **KY-08** | Bhawanrlal Gokulji Yadav Aahir, Farm Gangawana to Ladpura Road | Barley |
| **KY-10** | Farm of Kamruddin Medhri Mirzalli Gagwana Road, Behind Zine Mine | Crop |

### 4.2.2 Analysis methodology

**pH, conductivity and Fluoride:** Fixed amount of sample to water ratio was taken into beaker which was further kept for shaking for about half an hour, particles were allowed to settle down and pH and conductivity was measured by inserting the probes into the beaker, reading was allowed to stabilize and was noted down. Fluoride was also analysed in the deionised water supernatant after adding the TISAB buffer and using the fluoride ion selective electrode.

**Heavy Metals:** The soil samples were first dried in the oven, grinded, sieved and stored for heavy metal analysis. EPA 3052 protocol was used for the digestion of soil samples. Fixed amount of dried homogeneous soil was taken, to this 3:1 ratio of $HNO_3$ to HCl was added and this mixture was run on microwave digester for the particular inbuilt program. Sample obtained was diluted, filtered and was analysed on ICP-MS. The plant samples were also dried, grounded and digested with 4ml $HNO_3$ & 1ml $H_2O_2$ in microwave digester which were further analysed on ICP-MS.

## 4.3 Observations for Soil and Crop Samples

### 4.3.1 Soil Samples

**Table 4.3** & **4.4** shows pre-monsoon and post-monsoon physico-chemical parameters data.

**Table 4.3: Physcio-chemical Parameters of Soil Samples for Pre-monsoon Season**

| Sample Name | pH | Conductivity (µS/cm) | Fluoride (mg/kg) |
|---|---|---|---|
| **KY-01** | 8.21 | 245 | 0.03 |
| **KY-02** | **8.39** | **303** | **0.09** |
| **KY-03** | 7.62 | 2320 | 0.14 |
| **KY-04** | 7.99 | 2370 | 0.15 |
| **KY-05** | 9.05 | 2060 | 0.28 |
| **KY-06** | 7.28 | 2550 | 0.51 |
| **KY-07** | 7.72 | 556 | 0.19 |
| **KY-08** | 7.8 | 2370 | 0.05 |
| **KY-09** | 8.09 | 2320 | 0.31 |
| **KY-10** | 7.58 | 2830 | 0.25 |

**Table 4.4: Physcio-chemical Parameters of Soil Samples for Post-monsoon Season**

| Sample Name | pH | Conductivity (µS/cm) | Fluoride (mg/kg) |
|---|---|---|---|
| **KY-01** | 6.75 | 118.4 | 0.00 |
| KY-02 | 6.41 | 44.5 | 0.07 |
| **KY-03** | 7.81 | 121.7 | 0.11 |
| **KY-04** | 8.20 | 118.9 | 0.53 |
| **KY-05** | 7.26 | 79.3 | 0.27 |
| **KY-06** | 6.70 | 421.0 | 0.39 |
| **KY-07** | 7.22 | 72.8 | 0.21 |
| **KY-08** | 7.15 | 96.4 | 0.13 |
| **KY-09** | 6.75 | 658.0 | 0.15 |
| **KY-10** | 6.52 | 1580.0 | 0.08 |

**Table 4.5: Heavy Metals Data of Soil Samples for Pre-monsoon Season**

| Sr. No. | Samples | As | Ag | Cd | Co | Cr | Cu | Mn | Mo | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **KY-01** | 17.07 | 0.17 | BDL | 6.58 | 43.98 | 10.53 | 418.37 | 0.21 | 8.75 | 15.26 |
| 2 | **KY-02** | 7.95 | 0.12 | 0.11 | 7.92 | 38.38 | 16.32 | 499.97 | 0.29 | 12.19 | 22.94 |
| 3 | **KY-03** | 14.99 | 0.21 | 0.17 | 5.76 | 30.54 | 16.96 | 328.77 | 0.26 | 15.42 | 41.50 |
| 4 | **KY-04** | 18.83 | 0.14 | 0.14 | 9.09 | 49.58 | 11.94 | 405.57 | 0.58 | 15.68 | 33.34 |
| 5 | **KY-05** | 12.11 | 0.41 | 0.14 | 12.10 | 83.02 | 23.84 | 456.77 | 0.77 | 26.44 | 70.94 |
| 6 | **KY-06** | 9.07 | 0.73 | 0.41 | 10.43 | 49.90 | 30.88 | 680.77 | BDL | 39.40 | 125.98 |
| 7 | **KY-07** | 18.83 | 0.79 | BDL | 17.42 | 77.42 | 31.68 | 703.17 | 0.32 | 20.84 | 54.46 |
| 8 | **KY-08** | 17.71 | 0.88 | BDL | 16.62 | 78.70 | 25.60 | 643.97 | 0.25 | 22.44 | 75.74 |
| 9 | **KY-09** | 15.95 | 0.20 | 0.17 | 15.90 | 75.02 | 24.16 | 747.97 | BDL | 25.16 | 70.30 |
| 10 | **KY-10** | 15.15 | 0.70 | 0.27 | 16.14 | 81.90 | 35.84 | 818.37 | 0.46 | 31.08 | 121.98 |

**Table 4.6: Heavy Metals Data of Soil Samples for Pre-monsoon Season**

| Sr. No. | Samples | As | Ag | Cd | Co | Cr | Cu | Mn | Mo | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **KY-01** | 8.547 | 0.024 | BDL | 3.966 | 22.441 | 5.481 | 206.792 | BDL | 4.630 | 18.958 |
| 2 | **KY-02** | 13.513 | 0.054 | 0.020 | 6.023 | 23.819 | 9.581 | 266.880 | 0.14 | 4.523 | 26.936 |
| 3 | **KY-03** | 16.480 | 0.059 | 0.094 | 3.740 | 13.592 | 10.025 | 211.752 | 0.34 | 9.707 | 40.216 |
| 4 | **KY-04** | 17.813 | 0.024 | BDL | 6.100 | 20.915 | 6.196 | 289.483 | 0.09 | 4.480 | 20.118 |
| 5 | **KY-05** | 16.447 | 0.204 | BDL | 8.069 | 28.649 | 12.497 | 338.166 | BDL | 12.018 | 63.751 |
| 6 | **KY-06** | 12.513 | 0.123 | 0.096 | 5.951 | 23.992 | 12.240 | 466.054 | BDL | 18.198 | 51.098 |
| 7 | **KY-07** | 17.047 | 0.061 | BDL | 12.259 | 58.517 | 16.877 | 469.763 | BDL | 9.306 | 50.942 |
| 8 | **KY-08** | 20.280 | 0.139 | 0.038 | 9.510 | 44.527 | 13.851 | 438.868 | 0.44 | 14.447 | 64.023 |
| 9 | **KY-09** | 16.580 | 0.034 | 0.070 | 9.248 | 33.571 | 10.395 | 471.111 | 0.61 | 13.254 | 75.144 |
| 10 | **KY-10** | 19.913 | 0.156 | 0.065 | 9.375 | 48.689 | 17.765 | 487.853 | 0.59 | 15.877 | 95.606 |

**Table 4.7: Heavy Metals Data of Crops for Pre-monsoon Season**

| Location | As | Ag | Ba | Cd | Cu | Cr | Mo | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|
| KY-01 | 1.99 | 0.13 | 80.32 | 0.05 | 41.20 | 12.81 | 0.94 | 3.52 | 72.29 |
| KY-02 | 2.84 | 0.14 | 47.12 | 0.03 | 11.68 | 28.24 | 1.15 | 3.44 | 26.29 |
| KY-03 | 0.57 | 0.06 | 46.16 | 0.05 | 12.96 | 10.32 | 2.53 | 2.15 | 69.89 |
| KY-04 | 0.12 | 0.01 | 37.44 | 0.01 | 8.96 | 8.40 | 2.30 | 0.28 | 34.69 |
| KY-05 | 0.62 | 0.04 | 32.00 | BDL | 7.90 | 22.08 | 3.13 | 2.63 | 44.45 |
| KY-06 | 2.76 | 0.25 | 82.72 | 0.12 | 18.32 | 29.76 | 0.57 | 1.84 | 66.37 |
| KY-07 | 0.62 | 0.03 | 26.00 | 0.28 | 34.08 | 9.20 | 0.58 | 0.94 | 18.45 |
| KY-08 | 2.78 | 0.20 | 99.52 | 0.05 | 20.88 | 21.52 | 2.83 | 1.75 | 63.33 |
| KY-10 | 0.79 | 0.05 | 18.56 | 0.09 | 20.32 | 19.04 | 2.85 | 3.17 | 61.81 |

**Table 4.8: Heavy Metals Data of Crops for Post-monsoon Season**

| Location | As | Ag | Cd | Cr | Cu | Mo | Pb | Zn |
|---|---|---|---|---|---|---|---|---|
| **KY-02-I** | 0.44 | 0.03 | 0.01 | 12.75 | 0.531 | 0.45 | 1.41 | 22.20 |
| **KY-02-II** | 0.30 | 0.05 | 0.03 | 14.19 | 0.729 | 0.28 | 2.17 | 44.04 |
| **KY-02-III** | 0.61 | 0.05 | 0.05 | 11.35 | 0.359 | 2.82 | 0.81 | 12.60 |
| **KY-02-IV** | 0.71 | 0.08 | 0.05 | 4.21 | 0.441 | 4.27 | 3.23 | 25.56 |
| **KY-02-V** | 0.21 | 0.01 | 0.01 | 13.95 | 0.138 | 0.22 | 0.97 | 18.50 |
| **KY-03-I** | 0.80 | 0.04 | 0.01 | 14.30 | 1.965 | 2.31 | 1.87 | 35.88 |
| **KY-03-II** | 0.20 | 0.05 | 0.08 | 30.00 | 0.719 | 0.87 | 2.88 | 33.48 |
| **KY-03-III** | 0.64 | 0.05 | 0.13 | 18.94 | 0.430 | 1.19 | 5.56 | 61.36 |
| **KY-03-IV** | 0.65 | 0.04 | 0.06 | 16.23 | 0.420 | 3.61 | 2.70 | 43.36 |
| **KY-05-I** | 0.34 | 0.04 | 0.10 | 26.37 | 0.633 | 2.32 | 3.48 | 44.32 |
| **KY-05-I** | 0.10 | 0.08 | 0.14 | 25.41 | 0.783 | 0.91 | 0.45 | 88.72 |
| **KY-07-I** | 0.17 | 0.03 | 0.04 | 10.70 | 0.695 | 0.87 | 1.33 | 24.88 |
| **KY-07-II** | BDL | 0.03 | 0.05 | 12.71 | 0.461 | 0.30 | 0.64 | 38.04 |
| **KY-10-I** | 0.000 | 0.03 | 0.07 | 39.44 | 5.313 | 2.71 | 1.95 | 65.16 |
| **KY-10-II** | 0.000 | 0.02 | 0.12 | 22.13 | 0.477 | 2.89 | 2.85 | 59.40 |

## 4.4 Conclusions for Soil and Plant Analysis

### 4.4.1 Physical Parameters of Soil

The parameters that are considered for soil analysis were pH, Electrical conductivity (EC), Fluorides and metals considering the possible impacts of mining activities.

pH and conductivity are the most basic parameter indicating the nature of soil and indirect evidence of any possible contamination particularly related to metals. It has been reported that the soils nearby contaminated areas are associated with low pH values related with heterogeneous deposits of sulphidic residues at mine surroundings, which cause a decrease of the pH by sulphideoxidation and of sulfuric acid formation with metals. The results of pH, Conductivity and Fluorides during pre and post-monsoon seasons are presented in Table 4.3 and 4.4. pH of the soil samples from all the locations were observed to be slightly alkaline. During pre-monsoon seasons the soil pH was relatively more alkaline as compared to post-monsoon season. Soil conductivity was above 2 ds/m for most of the samples in pre-monsoon samples, whereas significant reduction in conductivity was observed for post-monsoon period indicting dilution due to rains. Fluorides were also analysed in soil samples considering its high concentrations in zinc ores and to ascertain any possible impacts due to mining activities. Fluorides in the soil samples were found to be within the naturally occurring range for both the pre-monsoon and post-monsoon seasons.

**Heavy Metals in Soils:**

The results of heavy metals distribution in soil samples around the mining area are presented in Tables 4.5 and 4.6 and brief description of distribution of metals are presented below:

Arsenic was found to be in the range of 8-18 mg/kg for the pre-monsoon batch which are well below the naturally occurring ranges. For the post-monsoon batch, concentration of As at most of the locations were observed to be below detection limits. Silver was found to be present in trace amount in all the samples of pre and post monsoon samples. Cadmium was also either below detection limits or present in traces in most of the samples in both pre and monsoon seasons. Concentration of Cd were observed to be in the range 0.08- 0.27 mg/kg during pre and post-monsoon seasons. Concentration of Co in pre-monsoon samples ranges between 6-16 mg/kg and for post-monsoon batch it was observed to be 4-13 mg/kg. As compared to other metals, relatively higher concentrations of Cr were observed in some of the locations during the pre-monsoon batch which reduces during post monsoon season. Concentration of Cr was found to be in the range 42-80 mg/kg.

Copper was also observed in the range of 11-30 mg/kg in pre-monsoon samples which reduces to almost 50% during post-monsoon season. The concentrations of Mn during pre-monsoon season were in the range of 350-800 mg/kg whereas for post-monsoon season it was observed to be in the range of 200-500 mg/kg, again showing the reduction in concentration during post monsoon season. Selenium and molybdenum were found in traces in soils samples for both pre and post monsoon batch. Relatively higher concentrations of lead and zinc were observed at several locations which may be due to naturally occurring levels owing to presence of zinc ore in this area which has also been observed in earlier studies in this area (EIA Studies). Lead was present in range of 9-40 mg/kg during pre-monsoon season which drastically reduce for the post-monsoon batch with concentrations ranging between 4-18 mg/kg. Most of the samples from pre-monsoon batch showed Zn concentrations in the range of 16-120 mg/kg and nearly same concentrations were observed in both the seasons.

### 4.4.2 Heavy Metals in Crops

The results of metals in various crop samples are presented in Tables 4.7 and 4.8 for pre and post monsoon season respectively. Arsenic and silver were found in all the crop samples in traces and in naturally occurring range. Barium was also observed in the range of 35-90 mg/kg for the pre-monsoon batch and relatively lower concentrations in post monsoon season. Cadmium concentration for pre-monsoon samples was observed in the range of 1.5-20 mg/kg. Relatively higher concentrations of Cr was observed in crops of some of the locations which are randomly distributed and also correlating with levels of Cr in soil. Molybdenum was found to be present in traces in the range of 0.57- 2.85 mg/kg. Lead was also present in traces and below the naturally occurring range. The Pb was found to be in the range of 0.28- 5.56 mg/kg for both the seasons. Zinc concentrations in plants samples were observed within the naturally occurring concentration in crop samples collected from all the locations.

Some of plants samples showed relatively higher concentrations of various metals as compared to other plant samples which are probably due to naturally occurring sources in the study area since the spatial correlation with the mining activities could not be established.

# Chapter 5: Assessment of Impact of mining activities on growth of vegetation within the lease area and carrying out ecological survey with a perspective to variety of plant species to be grown within the lease area.

## 5.1 Survey of Flora

*Prosopis juliflora* (Vilayti babool) is the main dominant species in most of the sampling area coming under dry deciduous environment. *Ficus religiosa* (Pipal), *Butea monosperma* (Dhak), *Syzygium cumini* (Jamun), *Azadirachta indica* (Neem) *and Ziziphus mauritiana* (Ber) are also found along with an abundance of various shrubs and grasses. *Citrus* (Lemon), *Terminalia catappa* (Badam), *Plumeria* (Chafa), *Phoenix dactylifera* (Khajoor) are planted near the study area. There are 14 different varieties of trees, 4 shrubs, 1 climber and 5 varieties of annual herbs and diverse grasses (**Table 5.1**) observed during the visit.

The area consists of desert plant near the vicinity of zinc mine and study area. Five sampling locations were demarcated covering vegetation in and around mining sites (**Table 5.2**). The mining sites are found to be free from ecologically sensitive and biologically rich areas/habitats, such as national parks, sanctuaries, biosphere reserves and areas rich in genetic resources. There are no rare, threatened and endangered plant species in the buffer zone.

**Figure 5.1: Satishji Kasad Farm Upstream Location-KY 3**

**Table 5.1: Plant Species recorded in the Study Area**

| Sr. No. | Vernacular Name | Botanical Names | Family |
|---|---|---|---|
| **Trees** | | | |
| 1. | Vilayti babool | *Prosopis juliflora* | *Fabaceae* |
| 2. | Desi Babool | *Vachellia nilotica* | *Fabaceae* |
| 3. | Gullar | *Ficus racemosa* | *Moraceae* |
| 4. | Peepal | *Ficus religiosa* | *Moraceae* |
| 5. | Dhak | *Butea monosperma* | *Fabaceae* |
| 6. | Jamun | *Syzygium cumini* | *Myrtaceae* |
| 7. | Lemon | *Citrus* | *Rutaceae* |
| 8. | Neem | *Azadirachta indica* | *Meliaceae* |
| 9. | Badam | *Terminalia catappa* | *Combretaceae* |
| 10. | Chafa | *Plumeria* | *Apocynaceae* |
| 11. | Orange | *Citrus sinensis* | *Rutaceae* |
| 12. | Ashoka | *Saraca asoca* | *Fabaceae* |
| 13. | Khajoor | *Phoenix dactylifera (date palm)* | *Arecaceae* |
| 14. | Khejari (Rajasthan state tree) | *Prosopis cineraria* | *Fabaceae* |
| **Shrubs** | | | |
| 1. | Ber | *Ziziphus mauritiana* | *Rhamnaceae* |
| 2. | Aak (Arka) | *Calotropis gigantea* | *Apocynaceae* |
| 3. | Ashwagandha | *Withania somnifera* | *Solanaceae* |
| 4. | Sesame | *Sesamum indicum* | *Pedaliaceae* |
| **Climbers** | | | |
| 1. | Bougainvillea | *Bougainvillea glabra* | *Nyctaginaceae* |
| **Herbs** | | | |
| 1. | Wheat (cereal grain) | *Triticum aestivum* | *Poaceae* |
| 2. | Jawar | *Sorghum* | *Poaceae* |
| 3. | Bajra (Pearl millet) | *Pennisetum glaucum* | *Poaceae* |
| 4. | Beans | *Leucaena leucocepha* | *Fabaceae* |
| 5. | Barley (Jao) | *Hordeum vulgare* | *Poaceae* |
| **Grasses** | | | |
| 1. | Duba grass (Doob) | *Cynodon dactylon* | *Poaceae* |
| 2. | Ban tulsi | *Croton bonplandianum* | *Euphorbiaceae* |
| 3. | Congress grass | *Parthenium hysterophorus* | *Asteraceae* |
| 4. | Grasses | *Unidentified* | *Unidentified* |

**Table 5.2: Locations of Biological Sampling**

| Sr. No. | Sampling Locations | Sample ID | Longitude (E) | Latitude (N) |
|---|---|---|---|---|
| **1.** | Upstream Location: Shivshankar Farm House (Control Location) | **KY 02** | 74°41'13.120"E | 26°35'31.475"N |
| **2.** | Upstream Location: Satishji Kasad Farm House | **KY 03** | 74°40'55.877"E | 26°30'40.974"N |
| **3.** | Farm behind the MDS University Auditorium Building. | **KY 05** | 74°68'33.929"E | 26°50'74.392"N |
| **4.** | Downstream Location: Devdatta Farm House. (Kayampura Road) | **KY 07** | 74°71'93.473"E | 26°55'55.337"N |
| **5.** | Kamruddin Medhri Farm House Mirzali Gagwana Road Behind Zinc mine (Orica plant) | **KY 10** | 74°41'51.757"E | 26°32'06.842"N |

## 5.2 Methodology

### 5.2.1 Dust Collection Potential Measurement

Dust collection potential of plants was recorded at 5 locations within the study area namely KY-02 Control (Shivshankar farm house), KY- 03 (Satishji Kasad farm), KY-5 (Farm behind to MDS Unit), KY-07 (Devdatta Farm) and behind the zinc mine location KY-10 (Farm of Kamruddin Medhri).

Leaves of broad leaved plant species were collected within the 5 km radius of the zinc mine. Three replicates of fully mature leaves of each species were marked. The upper dorsal surface of all these leaves was cleaned using a fine brush. All the leaves were left for three days to allow dust to accumulate on their surface. After three days the selected leaves were cut from the petiole and carefully taken to quantify dust accumulation. The individual leaf area was calculated by tracing marginal outline on a graph paper and average from three leaves was taken into consideration. The samples were weighed using an electrical 4 digit balance and the amount of dust was calculated using the equation $W = W2 - W1 / a$

Where:

W = Dust Content ($mg/cm^2$)

W1 = Weight of leaf with dust

W2 = Weight of leaf without dust

a = Total area of leaf in $cm^2$

**Figure 5.2: Dust Collection Potential Setup: *Calotropis gigantea***

### 5.2.2 Stomatal Studies

Stomata are the pores on a leaf surface through which plants regulate the uptake of carbon dioxide ($CO_2$) for photosynthesis against the loss of water via transpiration. Turgor changes in the guard cells determine the area of stomatal pore through which gaseous diffusion can occur, thus maintaining a constant internal environment within the leaf. Many atmospheric pollutants, even when present at relatively low concentrations, may interfere with the control of stomatal aperture, and they thus have the potential to upset the water balance of the leaf or the whole plant. Therefore, stomatal studies were conducted to determine the any possible impact of dust due to mining activities on the flora surrounding zinc mining area.

Three healthy leaves with their abaxial surface (underside) were selected. A clear nail varnish was applied to a 1 $cm^2$ patch on the right side of the main vein on the abaxial surface of each leaf to make a transparent imprint of the leaf. After drying, the nail varnish was removed with a piece of clear packing tape. The leaf was mounted on a clear microscopic slide. The leaf peel was examined under the microscope and photograph was taken at both 200 X & 400 X magnifications. The number of stomata and the density were calculated.

### 5.2.3 Importance Value Index (IVI)

A measure often used to describe and compare the species dominance of the plots is the Importance Value Index of Phillips; 1959. The IVI for a species is calculated as the sum of its relative dominance, its relative frequency and its relative density. The density measurements reflect as to how many individuals were present, the dominance measurements denote which species is largest in terms of its presence and the frequency measurements indicate how widely species is distributed among the same plots. Species occurring singular but with a high basal area may be given the same rank as widely spread but small species. Also, some species may be dominant in one site but do not occur at other sites. Importance value is a reasonable measure to assess the overall significance of a species since it takes into account several properties of the species in the vegetation. It also helps in ascertaining the impacts of anthropogenic activities on distribution and prevalence of various species. For IVI studies, 20 quadrates were laid out in the study area near the vicinity of mine area and number of trees of different species and their girth were noted down in each quadrate. Using this data IVI calculation was done using below mentioned calculations.

**Quantitative Analysis:**

The important quantitative analysis such as Relative density, Relative frequency, and Relative dominance of tree species, shrubs and herbs species were determined as (Phillips, 1959):

**Relative Density:**

Relative density is the study of numerical strength of a species in relation to the total number of individuals of all the species and can be calculated as:

$$\text{Remote Density} = \frac{\text{Number of Individuals of the Species}}{\text{Total Number of Individuals of all the Species}} \times 100$$

**a) Relative Frequency:**

The degree of dispersion of individual species in an area in relation to the number of all the species occurred.

$$\text{Remote Frequency (RF)} = \frac{\text{Number of Occurrence of Species (Frequency)}}{\text{Total No. of occurences of all Species (Sum of frequency)}} \times 100$$

**b) Relative Dominance:**

With dominance being an expression of the species richness and diversity describing the number of species in an area, these measures are appropriate in assessing the domination of a species in a set of species.

$$\text{Remote Dominance (RD)} = \frac{\text{Total basal area of Species}}{\text{Total basal area of all the Species}} \times 100$$

Where,

Basal area = $\pi r^2$ where r is radius (diameter/2) (Girth of the tree)

For total basal area of a species = Basal area x total number of that species

## 5.2.4 Air pollution Tolerance Index (APTI) Measurement

The leaf samples from the location of upstream and downstream sites namely KY-02 Control (Shivshankar farm house), KY- 03 (Satishji Kasad farm), KY-5 (Farm behind to MDS Unit), KY-07 (Devdatta Farm) and KY-10 (Farm of Kamruddin Medhri) behind the zine mine, were selected for analyzing APTI by taking the biochemical parameter of leaf namely pH, ascorbic acid, relative water content and total chlorophyll content.

The samples were collected from sites with similar light, water and soil conditions. Fresh leaf weight was taken. Dry weight (DW) was taken to express ascorbic acid (AA) content and total chlorophyll content (TCh). Samples were preserved at 4°C till AA, total chlorophyll and leaf extract pH analysis was carried out.

**APTI Calculations:** The APTI value was calculated referring to the formula given below.

APTI = A(T+P) +R / 10

Where:

A = Ascorbic acid content (mg/g)

P = pH of the leaf extract

T = Total chlorophyll content (mg/g)

R = Relative leaf water content (%)

**Relative Leaf Water Content (RWC)**

The method described by Liu and Ding (2008), was followed to determine RWC based on the formula:

RWC= (wf – wd) x 100 / (wt – wd)

Where, wf is fresh weight of the leaf, wt is turgid weight of the leaf after immersing into water overnight and wd is the dry weight of the leaf. Fresh weight (wf) of the leaf was increased when leaf pieces were weighed after immersing in water overnight to get turgid weight (wt). The leaf pieces were then blotted to dryness and placed in a dryer at 105˚C for 2 h and reweighed to get dry weight.

**Total Chlorophyll Content:**

For total chlorophyll content analysis, first 0.5 g of fresh leaves was taken and grounded with acid washed sand and acetone in a mortar. A subsample of 2.5 mL filtered sample was mesured for optical density at 645 nm (D645) and 663 nm (D663). Optical density of TCh (CT) is the sum of chlorophyll a (D645) density and chlorophyll b(D663) density (Liu and Ding 2008).

**Leaf Extract pH**

About 4 g of fresh leaves were homogenized in 40 mL deionized water and centrifuged at 7000 g. pH of the extract was measured with digital calibrated pH meter.

**Ascorbic Acid Content Analysis:**

1 g of fresh sample were weighed and crushed in to powder under liquid nitrogen environment, with 10 mL oxalic acid-EDTA solution. Diluted with DI water to 50 mL immediately to form solution A. from which 10 mL centrifuged at high speed (F=302.13g) for 10 min at room temperature. The liquid supernatant was separated as solution B. 5 mL of solution B was fully mixed with (1mL acetic acid solution, 2mL 5% sulphuric acid, 4 mL ammonium molybdate solution). Diluted with the distilled water up to 50mL. The final solution was measured by spectrophotometric method at 705 nm after incubation at room temperature for 15 min.

## 5.3 Observations

### 5.3.1 Dust Collection Potential Measurement

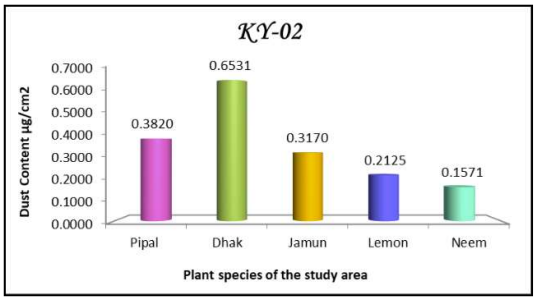
Dust collection potential measurements (DCPM) were carried out to ascertain the any possible of impact of dust generated due to mining activities on the surrounding vegetation. The studies were conducted locations surrounding the mining area nd at control location to compare the dust depositions due to mining and other anthropogenic activities. DCPM were carried out in randomly selected leaves of plant species present in the study area namely KY-02 Control (Shivshankar farm house), KY-03 (Satishji Kasad farm), KY-5 (Farm behind to MDS Unit), KY-07 (Devdatta Farm) and

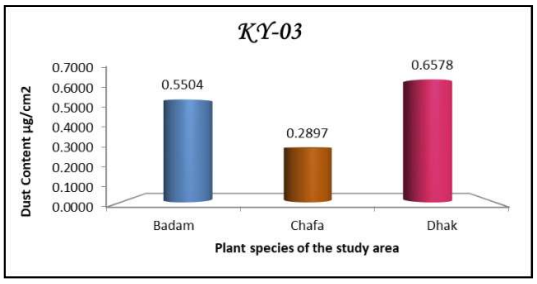
KY-10 near the zinc mine location (Farm of Kamruddin Medhri). Broad leaved plant species were selected for the determination of the dust collection potential.

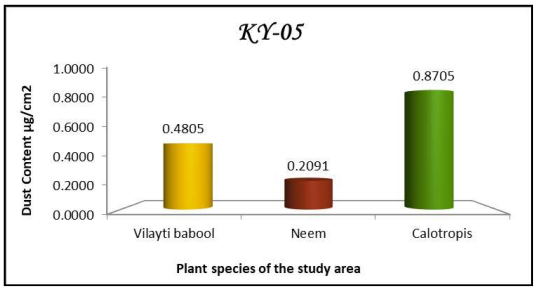
It was observed that the dust content was maximum in *Butea monosperma* (Dhak) followed by *Ficus religiosa* (Pipal), *Syzygium cumini* (Jamun), *Citrus* (Lemon) and least in *Azadirachta indica* (Neem) at KY-02 location. Similarly, In KY-03 location *Butea monosperma* (Dhak) had considerable high dust content than *Terminalia catappa* (Badam) and least in *Plumeria* (Chafa) whereas *Calotropis gigantea* (Calotropis), had high dust content than *Prosopis juliflora* (Vilayti babool) and least in *Azadirachta indica* (Neem) at KY-05 site. Furthermore the dust content was more in *Ficus religiosa* (Pipal) as compared to *Azadirachta indica* (Neem) in the KY-07 site whereas *Butea monosperma* (Dhak) had high dust content than *Ziziphus mauritiana* (Ber) and least in *Azadirachta indica* (Neem) at KY-10 site (**Figure 5.3**).

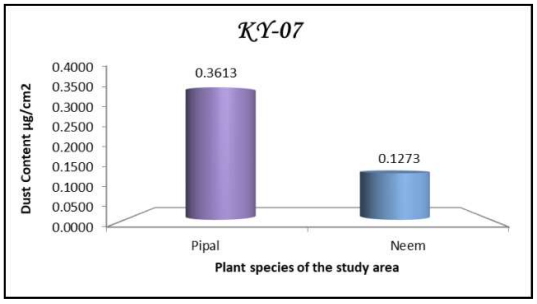
Dust reduces the growth of the plant species and also blocking of stomata at the rates varying from 0.03-6.3mg/cm$^2$/day (Rao, 1971). The dust collection potential of all the species, however, was extremely low as compared to the normally reported values. There are different reasons attributed for the dust holding capacity of plants. Dust interception and retention depends upon the leaf orientation, age, roughness and wettability of the leaf surface. It also depends upon the strength and constancy of the wind, the porosity of the vegetation with respect to the environment. For instance, among all the plant species studied for their dust collection potential, *Calotropis procera* (Calotropis) and *Butea monosperma* (Dhak) had maximum dust collection potentials. This may be due to the large leaf area of *Butea monosperma* which provides large room for the dust to deposit and the waxy coating on the *Calotropis procera* leaf which due to its sticky surface allows the dust to settle.

With all these morphological characters position/location of tree also plays an important role. If the tree is nearer to some dust source, industry, mine or site, the chance of getting more dust increases. However, it was observed that the values of DPCM were randomly distributed and some of the plants of even control location also showed elevated dust depositions indicating natural origin of the dusts. Since there were no apparent impacts seen in all these species, these can be ascribed to the fact that the dust collection potential values were reasonably low to inflict any negative impacts on the plants.



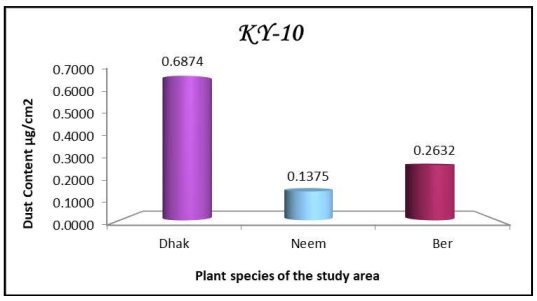




**Figure 5.3: Dust Collection Potential of Diverse Plant Species in the Study Area of Different Locations**

### 5.3.2 Stomatal Studies

Stomata, being the pathway of the entrance of most gaseous pollutants into the leaves, the study of the effects of air pollutants into the leaves thus become imperative. Many atmospheric pollutants, even when present in low concentrations, may interfere with the control of stomatal aperture, and they thus have the potential to upset the water balance of the leaf or the whole plant. Disturbances in stomatal control which can appear small in themselves may prove to be of great consequence with respect to the survival of the plant during a period of stress, which is within, the normal range of that in a variable natural environment. Usually, a high concentration of stomata indicates fast growth and wet climate. Lower concentrations of stomata indicate lower rates of photosynthesis and growth or adaptations for dry weather. Therefore, stomatal studies were conducted to determine the impact of dust on the flora surrounding the mining area.

Stomatal number and density (**Table 5.3**) were studied by microscopic stomatal examinations in plant species from study area. Microscopic observations (**Figure 5.5**) revealed the normal stomatal structures, with no blocked stomata indicating good stomatal health of the plants. Generally, blocking of stomata due to dust or other particulate matter can cause various adverse impacts on the health of the plants species viz. damage of guard cells, waxy layer over the cuticle which gets thin and ruptured. Moreover, stomatal health is affected to a great extent due to dust as a result of reduction in stomatal sizes, damage of oil gland, cuticle and epicuticular structures. However, no such impacts were observed during the study.

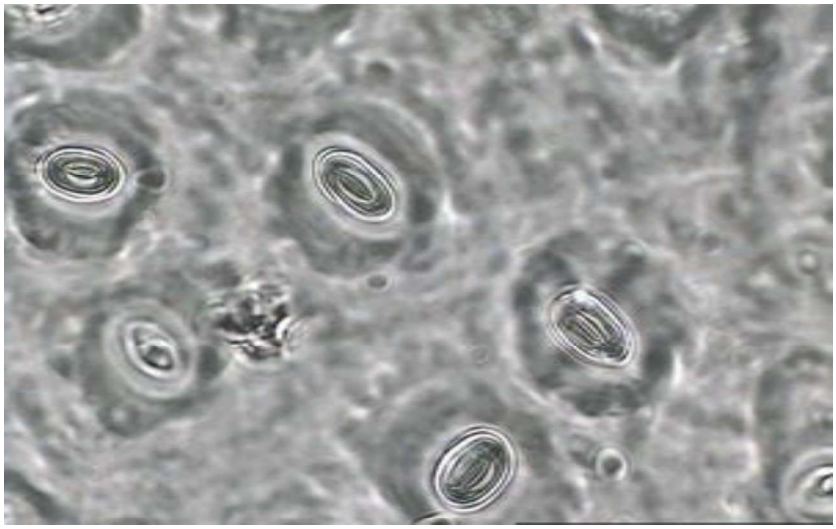


**Figure 5.4: Stomata of *Syzygium cumini* from the study area**

**Table 5.3: Stomatal Density Measurements in Plants of the Study Area**

| Stomatal Density | | Slide 1 | | Slide 2 | |
|---|---|---|---|---|---|
| **Locations** | **Plants** | **Average Stomata** | **Stomata /mm²** | **Average Stomata** | **Stomata /mm²** |
| **KY 02** | *Ficus religiosa* | 300.2 | 2401.6 | 287.8 | 2302.4 |
| | *Butea monosperma* | 90.2 | 721.6 | 70.2 | 561.6 |
| | *Syzygium cumini* | 288.6 | 2308.8 | 366.6 | 2932.8 |
| | *Citrus* | 394 | 3152 | 362.6 | 2900.8 |
| | *Azadirachta indica* | 272.4 | 2179.2 | 289 | 2312 |
| **KY 03** | *Terminalia catappa* | 285 | 2280 | 240.4 | 1923.2 |
| | *Plumeria* | 145.6 | 1164.8 | 152.8 | 1222.4 |
| | *Butea monosperma* | 37.4 | 299.2 | 46 | 368 |
| **KY05** | *Azadirachta indica* | 199.2 | 1593.6 | 196.8 | 1574.4 |
| | *Calotropis gigantea* | 182.8 | 1462.4 | 174.6 | 1396.5 |
| **KY07** | *Ficus religiosa* | 176.4 | 1411.2 | 159 | 1272 |
| | *Azadirachta indica* | 160.8 | 1286.4 | 167.2 | 1337.6 |
| **KY10** | *Butea monosperma* | 34.8 | 278.4 | 21.4 | 171.2 |
| | *Azadirachta indica* | 370.6 | 2964.8 | 263.2 | 2105.6 |
| | *Ziziphus mauritiana* | 172.4 | 1379.2 | 193.2 | 1545.6 |

### 5.3.3 Importance Value Index

Importance Value Index (IVI) describes the importance of the analyzed species; it weighs relative basal area dominance, relative density and relative frequency equally. This sometimes lead to the results that species occurring singular but with a big basal area due to their large girth, are given the same dominance as mostly small but widely spread species.

The results displayed (**Table 5.4**) that *Prosopis juliflora* (Vilayti babool) is the most important species. Their relative basal area dominance and relative density are leading to an overall high dominance. Second important tree species is *Azadirachta indica* (Neem) which has a high relative dominance as well as relative frequency. Other important tree species are *Butea monosperma* (Dhak), *Calotropis gigantea*

(Calotropis), *Ziziphus mauritiana* (Ber), *Ficus racemosa* (Gullar) and *Syzygium cumini* (Jamun). The less important species estimated with low IVI values are *Citrus sinensis* (Orange), *Terminalia catappa* (Badam) and *Phoenix dactylifera* (Khajoor). Their overall less relative dominance and relative frequency are leading to their low IVI values.

The dominance tree species is ***Prosopis juliflora*** (Vilayti babool) with their major contribution in total basal area and relative frequency indicates that these species utilize the majority of land space and resources belong to *Fabaceae* family **(Figure 5.5)**.

**Figure 5.5: IVI Studies in the Study Area (Site Ky-02 Control Location)**

**Table 5.4: IVI of Plant Species of Study Area**

| Sr. No. | Plant Species | Tot no. of individuals | Frequency % | Density | Abundance | Basal Area ($cm^2$) | Relative frequency | Relative density | Relative dominance | IVI |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ***Prosopis juliflora*** (Vilayti babool) | 45 | 60 | 4.5 | 7.5 | 27777.78 | 11.11 | 28.13 | 17.94 | 57.17 |
| 2 | ***Ficus racemosa*** (Gullar) | 7 | 20 | 0.7 | 3.5 | 16256.25 | 3.70 | 4.38 | 10.50 | 18.58 |
| 3 | ***Ficus religiosa*** (Peepal) | 6 | 30 | 0.6 | 2.0 | 8836.00 | 5.56 | 3.75 | 5.71 | 15.01 |
| 4 | ***Butea monosperma*** (Dhak) | 16 | 40 | 1.6 | 4.0 | 17777.78 | 7.41 | 10.00 | 11.48 | 28.89 |
| 5 | ***Syzygium cumini*** (Jamun) | 4 | 30 | 0.4 | 1.3 | 14400.00 | 5.56 | 2.50 | 9.30 | 17.35 |
| 6 | ***Citrus*** (Lemon) | 5 | 30 | 0.5 | 1.7 | 10000.00 | 5.56 | 3.13 | 6.46 | 15.14 |
| 7 | ***Azadirachta indica*** (Neem) | 16 | 70 | 1.6 | 2.3 | 11556.25 | 12.96 | 10.00 | 7.46 | 30.43 |
| 8 | ***Terminalia catappa*** (Badam) | 2 | 20 | 0.2 | 1.0 | 4225.00 | 3.70 | 1.25 | 2.73 | 7.68 |
| 9 | ***Plumeria Obtusa*** (Chafa) | 7 | 30 | 0.7 | 2.3 | 8556.25 | 5.56 | 4.38 | 5.53 | 15.46 |
| 10 | ***Ziziphus mauritiana*** (Ber) | 10 | 40 | 1 | 2.5 | 9025.00 | 7.41 | 6.25 | 5.83 | 19.49 |
| 11 | ***Vachellia nilotica*** (Desi babool) | 12 | 40 | 1.2 | 3.0 | 2025.00 | 7.41 | 7.50 | 1.31 | 16.22 |
| 12 | ***Citrus sinensis*** (Orange) | 2 | 20 | 0.2 | 1.0 | 2500.00 | 3.70 | 1.25 | 1.61 | 6.57 |
| 13 | ***Calotropis gigantea*** (Calotropis) | 17 | 40 | 1.7 | 4.3 | 6400.00 | 7.41 | 10.63 | 4.13 | 22.17 |
| 14 | ***Saraca asoca*** (Ashoka) | 5 | 30 | 0.5 | 1.7 | 4225.00 | 5.56 | 3.13 | 2.73 | 11.41 |
| 15 | ***Bougainvillea glabra*** (Bougainvillea) | 4 | 20 | 0.4 | 2.0 | 4900.00 | 3.70 | 2.50 | 3.16 | 9.37 |
| 16 | ***Phoenix dactylifera*** (Khajoor) | 2 | 20 | 0.2 | 1.0 | 6400.00 | 3.70 | 1.25 | 4.13 | 9.09 |
| | **Total** | **160** | **540** | | | **154860.31** | **100** | **100** | **100** | **300** |

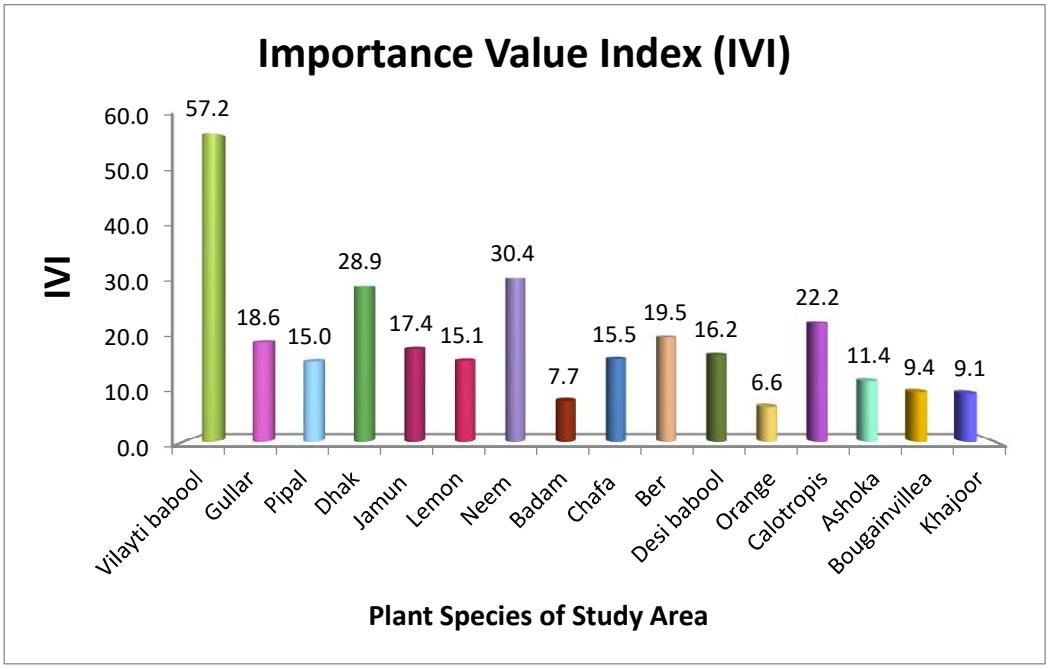



**Figure 5.6: IVI of Plant Species of Study Area**

The **Figure 5.6** Illustrate the information pertaining to Importance Value Index (IVI) of different plant species present in the study area. It is apparent from the results that *Prosopis juliflora* (Vilayti babool) exhibit IVI value of 57.2 whereas *Azadirachta indica* (Neem) plant shows IVI value 34.4. In addition to this, IVI of *Butea monosperma* (Dhak) tree is 28.9 and that of *Calotropis gigantea* (Calotropis) is 22.2. Furthermore IVI of *Ziziphus mauritiana* (Ber), *Ficus racemosa* (Gullar), *Syzygium cumini* (Jamun), *Vachellia nilotica* (Desi babool), *Plumeria Obtusa* (Chafa), *Citrus* (Lemon), *Ficus religiosa* (Peepal), *Saraca asoca* (Ashoka), *Bougainvillea glabra* (Bougainvillea), *Phoenix dactylifera* (Khajoor), *Terminalia catappa* (Badam) and Citrus sinensis (Orange) was 19.5, 18.6, 17.4, 16.2, 15.5, 15.1, 15.0, 11.4, 9.4, 9.1 , 7.7 and 6.6 respectively.

It is evidence from the results that *Prosopis juliflora* shows that highest IVI followed by *Azadirachta indica* whereas *Citrus sinensis* shows lowest IVI among all plant species present in the study areas. Further, it was also observed that all the observed species were randomly distributed at all the studied sites including control site confirming that there is no impact of mining activities on species prevalence and distribution.

### 5.3.4 Air Pollution Tolerance Index (APTI) Measurement

The Air Pollution Tolerance Index (APTI) gives an empirical value for tolerance level of plants to air pollution. The results of air pollution tolerance index (APTI) of different trees situated at location KY-02 exhibit that *Syzygium cumini* (Jamun) tree exhibit highest APTI which is 7.565, which was followed by *Citrus* (Lemon)

tree (6.255), *Butea monosperma* (Dhak) tree (5.603), *Azadirachta indica* (Neem) tree (5.415) and *Ficus religiosa* (Pipal) tree (1.959) which showed lowest APTI amongst all trees present at location KY-02. Similarly Air pollution tolerance index (APTI) of different trees situated at location KY-03 indicates that *Plumeria* (Chafa) tree exhibit highest APTI, which is 8.922, which was followed by *Terminalia catappa* (Badam) tree (7.567) and *Butea monosperma* (Dhak) tree (4.998) which showed lowest APTI amongst all trees present at location KY-03 **(Figure 5.7)**.

At location KY-05 *Calotropis* tree show highest APTI, which is 8.329, which was followed by *Azadirachta indica* (Neem) tree (5.313) and *Prosopis juliflora* (Vilayati Babul) tree (4.035) which showed lowest APTI amongst all trees present at this location. Similarly, APTI of different trees positioned at location KY-07 shows that *Azadirachta indica* (Neem) tree show highest APTI, which is 5.419 followed by *Ficus religiosa* (Pipal) tree (1.958) which showed lowest APTI amongst trees present at location KY-07. Furthermore, *Butea monosperma* (Dhak) tree show highest APTI, which is 7.547, followed by *Azadirachta indica* (Neem) tree (5.775) and *Ziziphus mauritiana* (Ber) tree (4.353) which showed lowest APTI amongst all trees present at location KY-10. It is evident from the APTI results that *Plumeria* (Chafa) plant exhibits highest APTI whereas *Ficus religiosa* (Pipal) tree exhibits lowest APTI among all available trees situated at different locations.

In addition to their high APTI and IVI values these species are also ecologically and economically significant accounting for their several uses (**Table 5.5**). The APTI and IVI measurements further establishes that there are no harmful impacts of mining activities around the mining area.

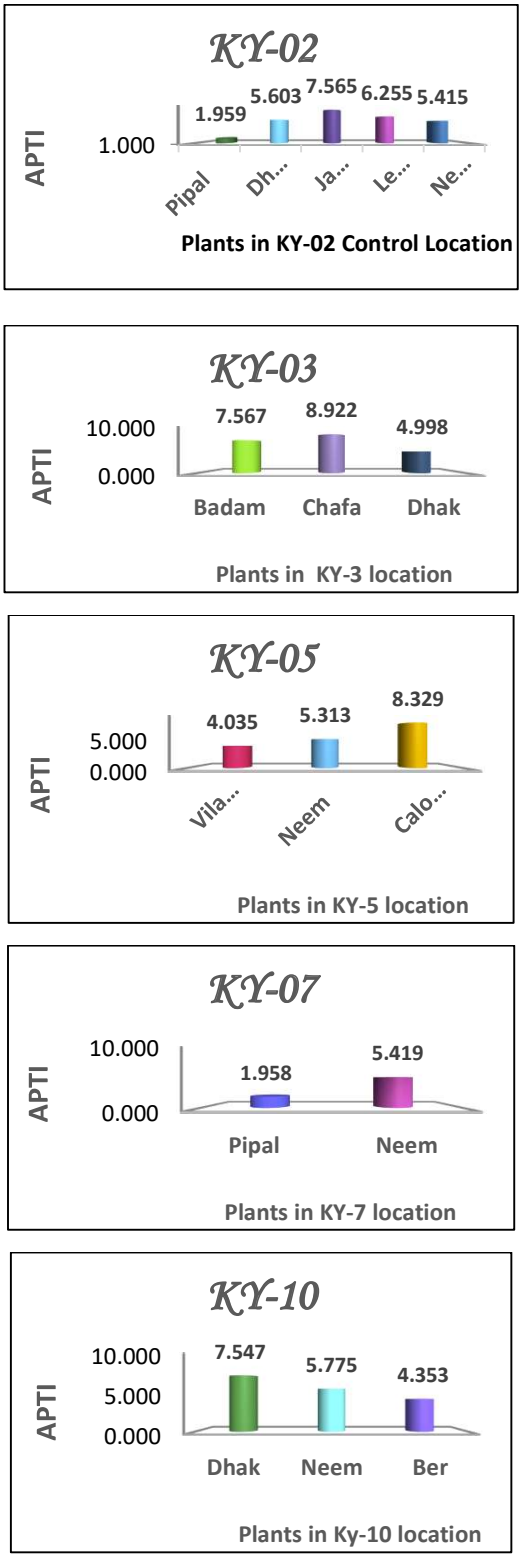



**Figure 5.7: APTI values of various Plant Species in different Locations of Study Area**

**Table 5.5: Ecologically and Economically important Plant Species in the Study Area with their respective APTI and IVI Values**

| Sr. No. | Name | Uses | Locations | APTI | IVI |
|---|---|---|---|---|---|
| 1. | ***Azadirachta indica*** (Neem) | • Dried and placed to prevent insects and mosquitoes<br>• Neem gum-rich source of protein<br>• Plant play important role for anthelminthic, antifungal, antidiabetic, antibacterial, antiviral<br>• Neem leaves-Treatment of skin diseases<br>• As a natural alternative to synthetic pesticides<br>• Wood for making shuttering grade plywood | KY 02<br>KY 05<br>KY 07<br>KY10 | 5.415<br>5.313<br>5.419<br>5.775 | 30.43 |
| 2. | ***Syzygium cumini*** (Jamun) | • Fruit- edible fruit with high nutritional value, also used for making wine and beer<br>• Leaves and Bark – for controlling blood pressure and gingivitis<br>• Seed use for medicine<br>• Seed- alternative healing systems like Ayurveda, Unani and Chinese medicine for digestive ailments | KY 02 | 7.565 | 17.35 |
| 3. | ***Ficus religiosa*** (Peepal) | • Almost every part of this tree i.e. leaves, bark, seeds and fruits are used in the preparation of herbal medicines.<br>• Highly rich in bioactive compounds namely flavonoids, alkaloids, tannins, saponins, phenols etc.<br>• Its antimicrobial, anti-diabetic, anticonvulsant, wound healing, anti-inflammatory and analgesic properties have made it a popular herbal tree and its parts are placed as important ingredient in modern pharmacological industry. | KY 02<br>KY 07 | 1.959<br>1.958 | 15.01 |
| 4. | ***Butea monosperma*** (Dhak) | • The most important use of this tree is as a host of a lac insect for production of *Rangini* lac.<br>• The leaves are lobed for fodder for buffalo and are used for making leaf plates and cups and beedi wrapping. | KY02<br>KY03<br>KY10 | 5.603<br>4.998<br>7.547 | 28.89 |

| Sr. No. | Name | Uses | Locations | APTI | IVI |
|---|---|---|---|---|---|
| | | • Flowers yield orange dye for colouring cotton fabrics but has little permanancy.<br>• Seeds used as vermifuge for elephants and horse.<br>• The bark particularly of roots yields a coarse brown fibre used for rough cordage and caulking boats. | | | |
| 5. | ***Citrus*** (Lemon) | • Leaves used in epilepsy, chorea, and convulsive coughs.<br>• fruits are rich in vitamins and minerals. Most of vitamin C is extracted from these fruits.<br>• Leaves are used in flavoring. The twigs used as tooth brushes. Oil of lemon is used in the preparation of mosquito oil.<br>• The large white fragrant flowers and fruits are in perfumes.<br>• Fruits are esteemed for deserts, made into jams and considered nutritive and refrigerant. | KY02 | 6.255 | 15.14 |
| 6. | ***Terminalia catappa*** (Badam) | • Almond contains health promoting compounds in its seed, hull, shell, skin, leaves and bark.<br>• The fruit has anti-diabetic, leaves antisickling and bark and root showed strong antimicrobial activities.<br>• Plant contains antioxidants such as terpenoids, triterpenoids, proanthocyanidins, flavonols and phenolic compounds.<br>• Almond consumption may reduce colon cancer risk<br>• Almond is considered a nutritive for the brain and nervous system. It is said to induce high intellectual level and longevity. | KY03 | 7.567 | 7.68 |
| 7. | ***Plumeria*** (Chafa) | • Bark is used as a stimulant, in decoction used as a purgative, febrifuge, and emmenagogue; also used in dropsical and venereal affections and said to be a powerful anti-herpatic. | KY03 | 8.922 | 15.46 |

| Sr. No. | Name | Uses | Locations | APTI | IVI |
|---|---|---|---|---|---|
| | | • Latex rubefacient and purgative; useful in treatments for itch, rheumatism, and gum troubles.<br>• Root cathartic.<br>• Wood used for making drums and other musical instruments supposed to be free from termites. | | | |
| 8. | ***Calotropis gigantea*** (Calotropis) | • An ideal plant for monitoring sulphur dioxide emissions in the air.<br>• The extremely poisonous roots are used in the treatment of snakebites<br>• The flower is digestive and tonic, leaves are used for the treatment of asthma and catarrh<br>• The root bark is an emetic. An infusion of bark powder is used in the treatment and cure of leprosy and elephantiasis<br>• The latex is used for treating ringworm, guinea worm blisters, scorpion stings, venereal sores and ophthalmic disorders<br>• The twigs are applied for the preparation of diuretics, stomach tonic and anti-diarrhoetics. Also used in abortion, as an anthelmintic, for colic, cough, whooping cough, dysentery, headache, lice treatment, jaundice, sore gums and mouth, toothache, sterility, swellings and ulcers<br>• Stems produce a good charcoal, while the stem pith makes good tinder | KY05 | 8.329 | 22.17 |
| 9. | ***Ziziphus mauritiana*** (Ber) | • An infusion of the flowers serves as an eye lotion. Fruits are rich in Vitamin C, A and B complex. The fruits are applied on cuts and ulcers; are employed in pulmonary ailments and fevers.<br>• The dried ripe fruit is a mild laxative. The seeds are sedative and are taken, sometimes with buttermilk, to halt nausea, | KY10 | 4.353 | 19.49 |

| Sr. No. | Name | Uses | Locations | APTI | IVI |
|---|---|---|---|---|---|
| | | vomiting, and abdominal pains in pregnancy. They check diarrhea, and are poulticed on wounds. Mixed with oil, they are rubbed on rheumatic areas.<br>• The leaves are applied as poultices and are helpful in liver troubles, asthma and fever and, together with catechu, are administered when an astringent is needed, as on wounds.<br>• The bitter, astringent bark decoction is taken to halt diarrhea and dysentery and relieve gingivitis. The bark paste is applied on sores.<br>• The root is purgative. A root decoction is given as a febrifuge, taenicide and emmenagogue, and the powdered root is dusted on wounds. | | | |
| 10. | ***Prosopis juliflora*** (Vilayti babool**)** | • Plant contains anti-bacterial, antifungal, anticancer, antioxidant, antimicrobial activity.<br>• It's a pleasing tree for fuel, charcoal, firewood and timber. It serves as one of the main sources of fuel for the rural people due to its excellent burning qualities.<br>• The extract of leaves shows very high antimicrobial activity.<br>• Plant is a deep rooted, sand dune stabilizers, multipurpose tree endemic to the hot deserts of India.<br>• Despite of number of uses it is known as serious invasive weed in most of the parts of world. | KY05 | 4.035 | 57.17 |

## 5.4 Conclusions for Plants Analysis

- There is no ecologically sensitive flora in the study area.
- Dust collection potential rates on the leaves was found to be less than the reported limits.

- Leaf injury symptom due to dust was also not observed.
- Although dust deposition was observed on leaves, microscopic studies revealed that deposition of dust is not having an adverse impact on the flora surrounding the zinc mine sites.
- Based on the parameters studied, it can be concluded that the adverse impact of dust on the surrounding flora of the mining area was not observed. Moreover the implementation of proposed massive plantation, cordoning the entire area and development of green belt area around it would bring significant positive impacts.

It is also advisable to implement regular monitoring program pertaining to flora and flora, so as to implement further mitigation measures including development of green belt.

# Chapter 6: Conclusions and Recommendations

- In view of possible environmental impacts due to various activities related to mining, HZL engaged CSIR-National Environmental Engineering Research Institute (CSIR-NEERI), Nagpur for carrying out a comprehensive environmental assessment study in and around the mine lease area with respect to:
  - Study on water bodies (surface and groundwater) in and around mine lease area for heavy metal and other physico-chemical parameters.
  - Monitoring of invertebrates and aquatic life (fish) of water bodies including the reservoir located close to the mining lease to assess bio accumulation of heavy metals, if any
  - Assessment of Impact of mining activities on soil quality and agriculture crops in the surrounding area with respect to Zinc, Cadmium and lead etc.
  - Assessment of Impact of mining activities on growth of vegetation within the lease area and carrying out ecological survey with a perspective to variety of plant species to be grown within the lease area
- Major Conclusions and recommendations with respect to these components are presented in the following sections.

**Study on water bodies (surface and groundwater) in and around mine lease area for heavy metal and other physico-chemical parameters.**

- The results of various physico-chemical parameters of water samples collected from various ground and surface water sources indicates that although pH was found to be near neutral range, conductivity & TDS of some samples were observed to be high which is characteristic of the surrounding area.
- The hardness of several water samples were also observed to be relatively on higher side.
- Fluorides were also observed in some of the samples beyond the drinking water permissible limits.
- Most of the samples shows lower values of physico-chemical parameters in post monsoon season indicating dilution effect due to rain water. The higher values of some of the physico-chemical parameters were randomly

distributed and no correlation with the mining activities were observed. Moreover, a survey of literature and earlier study reveals that the earlier reported water quality in the area is in line with the observed results.

- Concentrations of most of the metals were either below detection limits (BDL) or in traces (sub ppm levels). Clear trend of distribution of most of the metals w.r.t. upstream and downstream of the mining area and also in comparison with control location was not observed. Levels of several metals were even relatively higher in control location indicating presence due to natural origin and ruling out the impact due to mining activities.

**Monitoring of invertebrates and aquatic life (fish) of water bodies including the reservoir located close to the mining lease to assess bio accumulation of heavy metals, if any**

- The metals observed in different samples were mostly in the naturally occurring ranges and does not reflects accumulation due to mining activities. The control site also showed concentrations in similar ranges as that of other locations indicating that mining activities has not impacted the invertebrates.
- Fish and other aquatic faunal samples could not be collected as nearby ponds/lakes were dried during the time of sampling.

**Assessment of Impact of mining activities on soil quality and agriculture crops in the surrounding area with respect to Zinc, Cadmium and lead etc.**

- Results of pH during pre and post-monsoon seasons confirms slightly alkaline nature of soils around the mining area. Soil conductivity was reduced during post-monsoon period indicting dilution due to rains.
- Fluorides were also analysed in soil samples considering its high concentrations in zinc ores and to ascertain any possible impacts due to mining activities. Fluorides in the soil samples were found to be within the naturally occurring range for both the pre-monsoon and post-monsoon seasons.
- The monitoring of variety of heavy metals in soils around the mining area, indicated metal concentrations either below detection limits of within the naturally occurring range. The concentrations of metals in control location samples were also observed in similar ranges as of locations nearby mining area. These findings confirms that level of metals in soils around the mining area are not impacted due to mining activities.

- Most of the metals in crop samples showed concentrations in traces except for chromium which was observed in slightly higher concentrations at some of locations, but was observed within the naturally occurring ranges. Even the crop samples collected form control location showed relatively higher concentrations as compared to other and nearby locations confirming that the accumulation of these metals in crops is through naturally occurring geogenic sources and not due to mining activities.
- It can also be concluded from the extensive analysis data of heavy metals in various samples that pre-monsoon batch showed the relatively higher concentration of metals indicating dilution due to rains.

**Assessment of Impact of mining activities on growth of vegetation within the lease area and carrying out ecological survey with a perspective to variety of plant species to be grown within the lease area**

- The values of Dust Collection Potential Measurement (DPCM) were randomly distributed and some of the plants of even control location also showed elevated dust depositions indicating natural origin of the dusts. Since there were no apparent impacts seen in all these species, these can be ascribed to the fact that the dust collection potential values were reasonably low to inflict any negative impacts on the plants.
- Microscopic observations revealed the normal stomatal structures throughout the study area, with no blocked stomata indicating good stomatal health of the plants. Blocking of stomata due to dust or other particulate matter can cause various adverse impacts on the health of the plant species, however, no such impacts were observed during the study. Leaf injury symptom due to dust were also not observed.
- The Importance Value Index (IVI) studies revealed that Prosopis juliflora is the most dominant species followed by Azadirachta indica whereas Citrus sinensis is the least dominant species present in the study areas. Further, it was also observed that all the observed species were randomly distributed at all the studied sites including control site confirming that there is no impact of mining activities on species prevalence and distribution.
- The Air Pollution Tolerance Index (APTI) calculated for various representative plant species in the study area further establishes that there are no harmful impacts of mining activities on the vegetation around the mining area.
- It was also observed that is no ecologically sensitive flora or fauna in the study area.

- Based on the parameters studied, it can be concluded that the adverse impact of dust on the surrounding flora and fauna of the mining area was not observed. Moreover the implementation of proposed massive plantation, cordoning the entire area and development of green belt area around it would bring significant positive impacts.
- It is recommended that regular environmental monitoring and studies of possible impacts on flora and flora should be conducted to assess the impacts and suggest mitigation measures.

----------End of Report----------

# HINDUSTAN ZINC LIMITED
## KAYAD MINE

## AMBIENT AIR MONITORING

**Annexure-II**

| Location-> | | Mine Area | | | | | | Kayad | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| month-year | Forthnight | SPM | $PM_{10}$ | PM2.5 | $SO_2$ | $NO_x$ | CO | SPM | $PM_{10}$ | PM2.5 | $SO_2$ | $NO_x$ | CO |
| Oct-20 | Ist | 175.05 | 54.71 | 23.20 | 5.17 | 11.32 | 270.00 | 289.09 | 70.12 | 29.33 | 5.13 | 12.21 | 240.00 |
| | IInd | 165.80 | 54.79 | 25.39 | 4.52 | 11.10 | 270.00 | 242.63 | 73.58 | 27.99 | 6.07 | 13.24 | 280.00 |
| Nov-20 | Ist | 239.26 | 75.46 | 39.79 | 2.66 | 16.42 | 280.00 | 236.60 | 75.89 | 37.04 | 5.12 | 15.02 | 280.00 |
| | IInd | 363.08 | 78.25 | 44 | 4.46 | 17.78 | 290.00 | 251.78 | 72.85 | 41.72 | 6.83 | 14.53 | 310.00 |
| Dec-20 | Ist | 180.97 | 67.51 | 38.62 | 4.40 | 11.30 | 280.00 | 212.49 | 72.74 | 33.67 | 3.72 | 13.49 | 290.00 |
| | IInd | 190.98 | 72.49 | 34.47 | 3.71 | 10.93 | 290.00 | 253.15 | 61.89 | 41.62 | 4.67 | 16.58 | 380.00 |
| Jan-21 | Ist | 229.13 | 77.69 | 30.30 | 4.43 | 11.52 | 340.00 | 222.14 | 72.98 | 23.28 | 6.01 | 12.43 | 280.00 |
| | IInd | 238.46 | 76.33 | 41.93 | 4.98 | 12.39 | 340.00 | 240.26 | 75.79 | 31.05 | 5.90 | 11.61 | 340.00 |
| Feb-21 | Ist | 214.28 | 66.69 | 34.73 | 3.28 | 11.93 | 250.00 | 176.26 | 61.14 | 30.57 | 4.78 | 12.50 | 260.00 |
| | IInd | 258.18 | 77.52 | 29.07 | 2.59 | 11.88 | 340.00 | 287.05 | 69.81 | 33.48 | 1.64 | 11.90 | 270.00 |
| Mar-21 | Ist | 213.00 | 73.89 | 30.74 | 2.58 | 11.08 | 340.00 | 329.04 | 70.42 | 37.34 | 6.16 | 14.61 | 320.00 |
| | IInd | 212.14 | 75.52 | 36.68 | 6.28 | 12.53 | 340.00 | 121.33 | 62.99 | 34.22 | 4.60 | 13.07 | 320.00 |

| Location-> | | Lohagal | | | | | | Gagwana | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| month-year | Forthnight | SPM | $PM_{10}$ | PM2.5 | $SO_2$ | $NO_x$ | CO | SPM | $PM_{10}$ | PM2.5 | $SO_2$ | $NO_x$ | CO |
| Oct-20 | Ist | 270.52 | 81.66 | 27.80 | 7.00 | 14.60 | 280.00 | 225.83 | 71.72 | 29.33 | 6.09 | 23.25 | 280.00 |
| | IInd | 205.22 | 79.41 | 40.15 | 4.06 | 18.92 | 270.00 | 162.03 | 78.09 | 27.24 | 4.12 | 11.81 | 250.00 |
| Nov-20 | Ist | 287.79 | 76.70 | 34.72 | 4.24 | 16.91 | 280.00 | 308.90 | 64.21 | 40.11 | 4.70 | 17.98 | 310.00 |
| | IInd | 314.47 | 74.76 | 38.08 | 6.69 | 15.13 | 280.00 | 321.27 | 62.18 | 39.74 | 7.33 | 13.99 | 310.00 |
| Dec-20 | Ist | 195.10 | 72.42 | 37.64 | 3.35 | 17.95 | 250.00 | 239.55 | 71.41 | 39.02 | 5.76 | 12.70 | 270.00 |
| | IInd | 205.34 | 56.02 | 26.48 | 4.33 | 20.13 | 340.00 | 195.71 | 68.58 | 33.47 | 6.23 | 15.98 | 310.00 |
| Jan-21 | Ist | 174.55 | 63.35 | 27.75 | 3.33 | 11.34 | 270.00 | 203.88 | 69.99 | 28.71 | 5.06 | 12.16 | 310.00 |
| | IInd | 188.10 | 70.94 | 28.83 | 3.57 | 16.70 | 290.00 | 180.27 | 58.54 | 32.15 | 6.71 | 15.67 | 320.00 |
| Feb-21 | Ist | 210.95 | 81.20 | 31.92 | 3.81 | 11.97 | 320.00 | 236.00 | 66.35 | 26.91 | 4.53 | 13.82 | 260.00 |
| | IInd | 211.95 | 76.40 | 24.74 | 3.99 | 10.12 | 270.00 | 183.31 | 63.26 | 28.63 | 3.90 | 12.84 | 320.00 |
| Mar-21 | Ist | 249.39 | 80.91 | 39.05 | 4.49 | 20.07 | 270.00 | 356.21 | 67.48 | 36.47 | 7.58 | 18.52 | 300.00 |
| | IInd | 153.73 | 68.46 | 39.20 | 3.80 | 14.50 | 320.00 | 207.00 | 61.56 | 28.01 | 5.50 | 20.03 | 310.00 |

| Location-> | | Chatri | | | | | |
|---|---|---|---|---|---|---|---|
| month-year | Forthnight | SPM | $PM_{10}$ | PM2.5 | $SO_2$ | $NO_x$ | CO |
| Oct-20 | Ist | 208.02 | 71.51 | 34.22 | 5.24 | 15.56 | 260.00 |
| | IInd | 181.50 | 70.78 | 27.78 | 5.30 | 10.37 | 240.00 |
| Nov-20 | Ist | 226.48 | 76.93 | 40.64 | 5.06 | 15.98 | 250.00 |
| | IInd | 279.20 | 72.60 | 28.61 | 6.38 | 11.66 | 280.00 |
| Dec-20 | Ist | 156.76 | 60.11 | 35.12 | 4.71 | 13.61 | 280.00 |
| | IInd | 190.36 | 67.38 | 26.69 | 6.07 | 10.3 | 340.00 |
| Jan-21 | Ist | 179.57 | 75.92 | 21.63 | 5.76 | 11.90 | 290.00 |
| | IInd | 281.85 | 76.66 | 26.21 | 5.41 | 10.66 | 320.00 |
| Feb-21 | Ist | 249.50 | 71.38 | 34.17 | 6.43 | 13.52 | 240.00 |
| | IInd | 174.79 | 64.17 | 18.76 | 3.84 | 11.31 | 270.00 |
| Mar-21 | Ist | 356.21 | 67.48 | 36.47 | 7.58 | 18.52 | 300.00 |
| | IInd | 155.46 | 44.90 | 22.66 | 5.46 | 14.99 | 310.00 |

Sensitivity: Internal (C3)

## Water level of Piezometers & open wells
## Surrounding Kayar mines, District Ajmer (Raj.)

**Annexure III**

| S.No. | Source Code | Location with land mark | Lattitude | Longitude | WL (BGL) (in mt) 25/11/2020 | WL (BGL) (in mt) 11/02/20210 |
|---|---|---|---|---|---|---|
| 1 | P-1 | Piezometer-1, near VTC- HZL | N26°31'44.1'' | E74°41'19.2'' | 19.10 | 23.90 |
| 2 | P-2 | Near mine dumped area, HZL fuel pump | N26°31'56.9'' | E74°41'41.1'' | 14.30 | 15.20 |
| 3 | P-3 | Plantation area, nursery, near other collapsed bore well | N26°32'10.0'' | E74°41'44.4'' | 13.80 | 14.10 |
| 4 | P-4 | New drilled bore well, near ANFO Mixing plant, HZL boundary wall corner | 26°32'02.0'' | 74°41'45.2'' | 9.20 | 9.20 |
| 5 | P-5 | New drilled bore well, DG Set area | 26°31'40.3'' | 74°41'29.1'' | 12.50 | 12.80 |
| 6 | W-1 | Man Singh Raghuveer singh Chandawal, Kayar/ Naeem Bhutta | N26°33'25.7'' | E74°41'45.9'' | 13.10 | 14.00 |
| 7 | W -2 | Gurjar Well Near Abkar Minar and ARG opp SK associates | N26°32'48.6'' | E74°42'24.8'' | 19.50 | 23.80 |
| 8 | W-3 | Near Talab area, land planning by propoerty dealers/ poltary farm | N26°32'08.3'' | E74°42'27.7'' | 18.60 | 20.70 |
| 9 | W-4 | Mohan Gurjar Well Kayad | N26°31'11.7'' | E74°41'02.7'' | 14.3 | 15.2 |
| 10 | W-5 | Near outside HZL boundary wall, near outside HZL road area | N26°31'52.7'' | E74°41'36.0'' | 23.2 | 26.2 |
| 11 | W-6 | Near Govt. School/Mr. Sultan Master, Kamurdin Nizam ji Kayar | N26°31'38.7'' | E74°41'11.3'' | 14.10 | 14.30 |

Sensitivity: Public (C4)

## Piezometer water quality monitoring data Annexure-IV

| | P-1 | | P-2 | | P-3 | | P-4 | | P-5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | Dec-20 | Mar-21 | Dec-20 | Mar-21 | Dec-20 | Mar-21 | Dec-20 | Mar-21 | Dec-20 | Mar-21 |
| pH | 6.82 | 7.58 | 6.9 | 7.83 | 7.69 | 7.99 | 7.28 | 7.58 | 7.2 | 7.57 |
| Hardness | 808.08 | 894.23 | 656.57 | 721.15 | 525.25 | 461.54 | 450 | 576.92 | 550 | 817.31 |
| Iron | BDL | 0.04 | BDL | 0.04 | 0.02 | BDL | 0.04 | 0.11 | 0.03 | BDL |
| Chloride | 482.9 | 684.04 | 492.76 | 403.78 | 468.12 | 378.12 | 320.29 | 451.28 | 482.9 | 912.06 |
| TDS | 2745 | 3166 | 1814 | 1966 | 2487 | 2087 | 2165 | 2091 | 3267 | 3045 |
| Copper | BDL | BDL | BDL | BDL | BDL | BDL | BDL | 0.02 | 0.01 | BDL |
| Sulphate | 358.8 | 384.44 | 188.8 | 294.44 | 355.5 | 315.28 | 322.2 | 348.8 | 353 | 214.44 |
| Cadmium | 0.002 | BDL | 0.002 | BDL | 0.001 | BDL | BDL | BDL | 0.004 | BDL |
| Lead | 0.03 | BDL | 0.05 | BDL | 0.01 | BDL | 0.06 | 0.01 | 0.03 | BDL |
| Zinc | 0.15 | 0.03 | 0.08 | BDL | 0.13 | 0.08 | 0.16 | 0.02 | 0.4 | BDL |
| Alkalinity | 393.6 | 356.4 | 393.6 | 435.6 | 556.8 | 475.2 | 86.4 | 128.7 | 480 | 495 |
| Nickel | BDL | BDL | BDL | BDL | 0.02 | BDL | BDL | 0.03 | 0.02 | BDL |
| Cyanide | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| Cobalt | 0.01 | BDL | 0.02 | BDL | 0.02 | BDL | 0.02 | 0.04 | 0.02 | BDL |
| TSS | 7 | 6 | 11 | 7 | 7 | 5 | 5 | 8 | 9 | 7 |
| Total solid | 2752 | 3172 | 1825 | 1973 | 2494 | 2092 | 2170 | 2099 | 3276 | 3052 |

All figureas are in mg/l except pH

.Sensitivity: Internal (C3)

## Ground water Quality Monitoring around mine lease area

**Annexure-V**

| Parameters | Kayad Village U/S (Handpump water) GW1 | | Gagwana Village D/S (Borewell Water) GW2 | | | Chatri Village D/S (Handpump Water) GW3 | | | Lohagal Village U/S (Borewell Water) GW5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dec-20 | Mar-21 | Baseline | Dec-20 | Mar-21 | Baseline | Dec-20 | Mar-21 | Baseline | Dec-20 | Mar-21 |
| pH | 8.03 | 8.13 | 7.1 | 8.55 | 8.46 | 7.5 | 7.14 | 7.71 | 6.9 | 7.53 | 8.06 |
| Hardness | 315.15 | 103.85 | 306 | 252.53 | 88.46 | 1366 | 777.78 | 192.31 | 1233 | 1060.61 | 265.38 |
| Iron | BDL | BDL | 0.19 | BDL | BDL | 0.2 | 0.11 | BDL | 0.18 | BDL | BDL |
| Chloride | 167.54 | 55.1 | 536 | 354.78 | 62.7 | 1842 | 211.88 | 608.04 | 1060 | 970.73 | 318.27 |
| TDS | 664 | 293 | 812 | 1643 | 313 | 4746 | 1814 | 1814 | 4512 | 4025 | 1612 |
| Copper | BDL | BDL | <0.01 | BDL | BDL | <0.01 | 0.03 | BDL | <0.01 | 0.03 | BDL |
| Sulphate | 62.22 | 28.55 | 302 | 220.2 | 34.22 | 512.6 | 217.7 | 200 | 666.8 | 422.22 | 71.66 |
| Cadmium | 0.002 | BDL | <0.01 | BDL | BDL | <0.01 | 0.003 | BDL | <0.01 | 0.005 | BDL |
| Arsenic | BDL | BDL | <0.01 | BDL | BDL | <0.01 | BDL | BDL | <0.01 | BDL | BDL |
| Lead | BDL | BDL | 0.01 | BDL | BDL | 0.01 | 0.01 | BDL | 0.01 | 0.08 | BDL |
| Zinc | 0.03 | BDL | 0.1 | BDL | BDL | 0.06 | 0.15 | BDL | 0.32 | 0.02 | BDL |
| Alkalinity | 249.6 | 102.96 | 456 | 326.4 | 83.16 | 524 | 412.8 | 455.4 | 486 | 403.2 | 590.04 |
| TSS | 16 | 8 | - | 11 | 10 | | 12 | 4 | | 15 | 7 |
| Cobalt | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | 0.01 | BDL |
| Mercury | BDL | BDL | <0.001 | BDL | BDL | <0.001 | BDL | BDL | <0.001 | BDL | BDL |
| Cyanide | BDL | BDL | <0.02 | BDL | BDL | <0.02 | BDL | BDL | <0.02 | BDL | BDL |
| Nickel | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| Total solid | 670 | 301 | | 1654 | 323 | | 1826 | 1818 | | 4040 | 1619 |

All figureas are in mg/l except pH

Sensitivity: Internal (C3)

## pH meter Reading of Mine Water

## Annexure-VI

| Oct-20 | | Nov-20 | | Dec-20 | |
|---|---|---|---|---|---|
| **Date** | pH | Date | pH | Date | pH |
| 01/10/2020 | 7.1 | 01/11/2020 | 7.0 | 01/12/2020 | 7.0 |
| 02/10/2020 | 7.0 | 02/11/2020 | 6.9 | 02/12/2020 | 7.0 |
| 03/10/2020 | 7.0 | 03/11/2020 | 7.0 | 03/12/2020 | 6.9 |
| 04/10/2020 | 7.0 | 04/11/2020 | 6.9 | 04/12/2020 | 7.0 |
| 05/10/2020 | 7.1 | 05/11/2020 | 7.0 | 05/12/2020 | 7.1 |
| 06/10/2020 | 7.1 | 06/11/2020 | 6.9 | 06/12/2020 | 7.1 |
| 07/10/2020 | 7.0 | 07/11/2020 | 6.8 | 07/12/2020 | 7.0 |
| 08/10/2020 | 6.9 | 08/11/2020 | 6.8 | 08/12/2020 | 6.9 |
| 09/10/2020 | 6.9 | 09/11/2020 | 6.9 | 09/12/2020 | 6.9 |
| 10/10/2020 | 7.0 | 10/11/2020 | 6.9 | 10/12/2020 | 7.0 |
| 11/10/2020 | 7.0 | 11/11/2020 | 7.0 | 11/12/2020 | 7.0 |
| 12/10/2020 | 6.9 | 12/11/2020 | 6.8 | 12/12/2020 | 6.9 |
| 13/10/2020 | 6.8 | 13/11/2020 | 6.9 | 13/12/2020 | 6.8 |
| 14/10/2020 | 6.7 | 14/11/2020 | 6.8 | 14/12/2020 | 6.7 |
| 15/10/2020 | 6.8 | 15/11/2020 | 6.9 | 15/12/2020 | 6.7 |
| 16/10/2020 | 6.9 | 16/11/2020 | 7.0 | 16/12/2020 | 6.6 |
| 17/10/2020 | 7.0 | 17/11/2020 | 7.1 | 17/12/2020 | 6.7 |
| 18/10/2020 | 7.0 | 18/11/2020 | 7.0 | 18/12/2020 | 6.8 |
| 19/10/2020 | 7.1 | 19/11/2020 | 7.0 | 19/12/2020 | 6.9 |
| 20/10/2020 | 7.0 | 20/11/2020 | 6.9 | 20/12/2020 | 7.0 |
| 21/10/2020 | 6.9 | 21/11/2020 | 7.0 | 21/12/2020 | 7.0 |
| 22/10/2020 | 6.9 | 22/11/2020 | 7.0 | 22/12/2020 | 6.9 |
| 23/10/2020 | 6.8 | 23/11/2020 | 7.1 | 23/12/2020 | 6.8 |
| 24/10/2020 | 6.7 | 24/11/2020 | 7.0 | 24/12/2020 | 6.8 |
| 25/10/2020 | 6.7 | 25/11/2020 | 6.9 | 25/12/2020 | 6.9 |
| 26/10/2020 | 6.8 | 26/11/2020 | 7.0 | 26/12/2020 | 6.9 |
| 27/10/2020 | 6.8 | 27/11/2020 | 6.9 | 27/12/2020 | 7.0 |
| 28/10/2020 | 6.9 | 28/11/2020 | 7.0 | 28/12/2020 | 7.1 |
| 29/10/2020 | 7.0 | 29/11/2020 | 7.0 | 29/12/2020 | 7.0 |
| 30/10/2020 | 7.1 | 30/11/2020 | 6.9 | 30/12/2020 | 6.9 |
| 31/10/2020 | 6.9 | | | 31/12/2020 | 6.9 |

.Sensitivity: Internal (C3)

## pH meter Reading of Mine Water

| Jan-21 | | Feb-21 | | Mar-21 | |
|---|---|---|---|---|---|
| **Date** | pH | Date | pH | Date | pH |
| 01/01/2021 | 7.0 | 01/02/2021 | 7.0 | 01/03/2021 | 7.1 |
| 02/01/2021 | 7.1 | 02/02/2021 | 6.9 | 02/03/2021 | 7.0 |
| 03/01/2021 | 7.0 | 03/02/2021 | 6.9 | 03/03/2021 | 6.9 |
| 04/01/2021 | 6.9 | 04/02/2021 | 6.8 | 04/03/2021 | 6.9 |
| 05/01/2021 | 6.9 | 05/02/2021 | 6.9 | 05/03/2021 | 7.0 |
| 06/01/2021 | 6.8 | 06/02/2021 | 6.9 | 06/03/2021 | 7.1 |
| 07/01/2021 | 6.7 | 07/02/2021 | 7.0 | 07/03/2021 | 7.0 |
| 08/01/2021 | 6.8 | 08/02/2021 | 6.9 | 08/03/2021 | 6.9 |
| 09/01/2021 | 6.8 | 09/02/2021 | 7.0 | 09/03/2021 | 6.9 |
| 10/01/2021 | 6.9 | 10/02/2021 | 6.9 | 10/03/2021 | 7.0 |
| 11/01/2021 | 7.0 | 11/02/2021 | 6.9 | 11/03/2021 | 7.0 |
| 12/01/2021 | 7.0 | 12/02/2021 | 7.0 | 12/03/2021 | 6.9 |
| 13/01/2021 | 7.0 | 13/02/2021 | 7.1 | 13/03/2021 | 6.9 |
| 14/01/2021 | 6.9 | 14/02/2021 | 7.2 | 14/03/2021 | 7.0 |
| 15/01/2021 | 6.9 | 15/02/2021 | 7.1 | 15/03/2021 | 7.0 |
| 16/01/2021 | 6.8 | 16/02/2021 | 7.2 | 16/03/2021 | 6.9 |
| 17/01/2021 | 6.8 | 17/02/2021 | 7.3 | 17/03/2021 | 7.0 |
| 18/01/2021 | 6.9 | 18/02/2021 | 7.3 | 18/03/2021 | 7.0 |
| 19/01/2021 | 7.0 | 19/02/2021 | 7.4 | 19/03/2021 | 7.1 |
| 20/01/2021 | 7.1 | 20/02/2021 | 7.4 | 20/03/2021 | 6.9 |
| 21/01/2021 | 7.2 | 21/02/2021 | 7.3 | 21/03/2021 | 7.0 |
| 22/01/2021 | 7.1 | 22/02/2021 | 7.3 | 22/03/2021 | 6.9 |
| 23/01/2021 | 7.2 | 23/02/2021 | 7.4 | 23/03/2021 | 7.0 |
| 24/01/2021 | 7.0 | 24/02/2021 | 7.3 | 24/03/2021 | 6.9 |
| 25/01/2021 | 6.9 | 25/02/2021 | 7.2 | 25/03/2021 | 7.0 |
| 26/01/2021 | 7.0 | 26/02/2021 | 7.2 | 26/03/2021 | 6.9 |
| 27/01/2021 | 6.9 | 27/02/2021 | 7.1 | 27/03/2021 | 6.8 |
| 28/01/2021 | 6.8 | 28/02/2021 | 7.0 | 28/03/2021 | 6.8 |
| 29/01/2021 | 6.8 | | | 29/03/2021 | 6.9 |
| 30/01/2021 | 6.9 | | | 30/03/2021 | 7.0 |
| 31/01/2021 | 7.0 | | | 31/03/2021 | 6.9 |

.Sensitivity: Internal (C3)