Hazards associated with Refining of Gold

MMTC-PAMP

London, 13 Mar 2023

An MKS PAMP GROUP Company

MMTC-PAMP- most trusted precious metal ecosystem

MMTC-PAMP

REFINER

Only LBMA Accredited Gold and Silver Refinery in India

Products covering entire value chain for customers

For B2B Customers

- ✓ Bullion
- ✓ Master Alloys
- ✓ Minted Products
- ✓ Old Gold Recycling
- ✓ Industrial products
- ✓ Standard Reference Material

For Retail Customers

- ✓ Gold and Silver Coins
- ✓ Digital Gold
- ✓ Buyback of Old Gold

Presence Across Digital and Physical Channels

- ✓ Counters across 145 cities
- ✓ More than 700 jewellers
- ✓ Across Amazon, Flipkart, AJIO and own platforms

Government and Industry Stakeholders

- Indian Government Mint
- BIS Hallmarking
- World Gold Council
- Swiss India Chamber of Commerce

MMTC-PAMP has put India on the global map of precious metals

1 WORLD'S HIGHEST STANDARD OF QUALITY

- The **only LBMA accredited Good Delivery** Gold and Silver refinery in India.
- The only mint outside UK to be **licensed by Royal Mint for minting Sovereigns**.
- **BIS accreditation** for 999 and 995 Gold 100 g and 1 Kg bullion bar

2 BRINGING RESPONSIBLE GOLD TO INDIA

- India's first and only LBMA independently audited and certified **Responsible Gold & Silver compliant refinery.**
- Certified (audited) member of **Responsible Jewellery Council** and member of its global board.
- **CII Sustainability Plus gold certificate 2016**
- Certified by **Responsible Jewellery Council (RJC)** for COP (Code of Practice) and CoC (Chain of custody) standards

3 IMPECCABLE MANUFACTURING STANDARD

- **SA 8000 certified**, a first for any precious metals refinery in Asia and one of only two such in the world
- ISO 9001:2015, ISO 14001:2015, ISO 45001:2018, ISO 50001:2018 certified facility.
- **Accreditation for ISO 17025:2017**

4 LEADING LOCAL INNOVATION & POLICY

Best Refinery award from:

- Bullion Federation & ASSOCHAM –4 since 2016
- IIGC & IBJA – 5 times since 2013
- GJTCI – 1 times since 2018

Hazards associated with Refining of Gold

Contents

1. Background – Processes in Refinery

2. Risks associated in gold refining

3. Various Hazards and Control measures
   - Fumes
   - Molten metal
   - Effluent

4. Regulatory norms - Monitoring by MMTC-PAMP

5. Q & A

Introduction

- Primary Recovery and refining of gold from dore, jewellery scrap and other waste involves use of **Pyrometallurgical** processes.

- **Chemical & electrochemical** techniques such as Inquartation & Parting, Aqua regia, Electrolysis etc. are mostly used to achieve a purity of 99.9% and more.

- The **impurities** which are usually associated with gold are varied namely Ag, Cu, Zn, Sn, Fe, Ni, Co, Bi, Al, Te, Se Cd, Pb , PGM (Ir, Ru, Os) which needs to be removed to arrive at required fineness. This can be estimated by proper analysis before we start the process

- The selection of the **refining technique** depends on various factors such as:

- end product requirement
- gold content and impurity content including Silver
- physical and chemical characteristics of the material
- inventory holding capability
- economic feasibility based on factors such as quantity , availability, location etc.
- available expertise and skills
- safety & environmental regulations .

Processes in Refinery

1. Pyrometallurgical process
2. Inquartation and Parting
3. Chemical Refining - Aqua Regia digestion and precipitation
4. Electrochemical Refining

Major Pyrometallurgical Techniques

The main processes used for Gold Recovery and Refining are as follows:

1. Incineration Burning of waste material having precious metal with an aim to remove moisture and organics

2. Volatilization Removing all metal including silver by applying vacuum and heat

3. Oxidation

a. Roasting - Eliminates oxidizable metals such as Se, Zn, As etc. as fumes

b. Cupellation - using lead to remove all base metal and leave gold and silver as alloy

4. Chlorination Purging of pure chlorine in molten metal and base metal as insoluble chloride (Miller process)

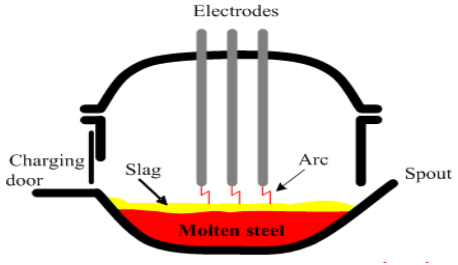
Equipment used in Pyrometallurgical process

Incineration

Induction furnace
(Induction heating)

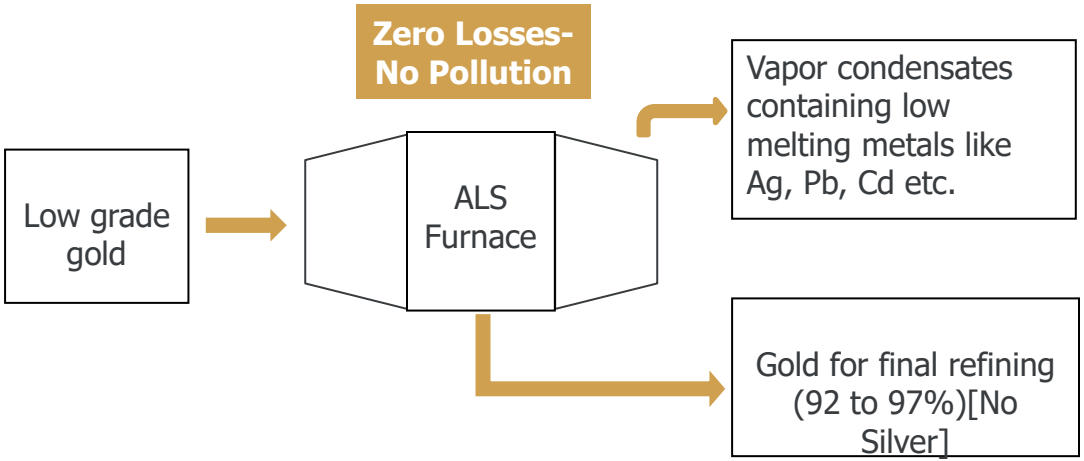
Mini Resistance
Furnace

Top Blown Rotary
Furnace (fuel fired)

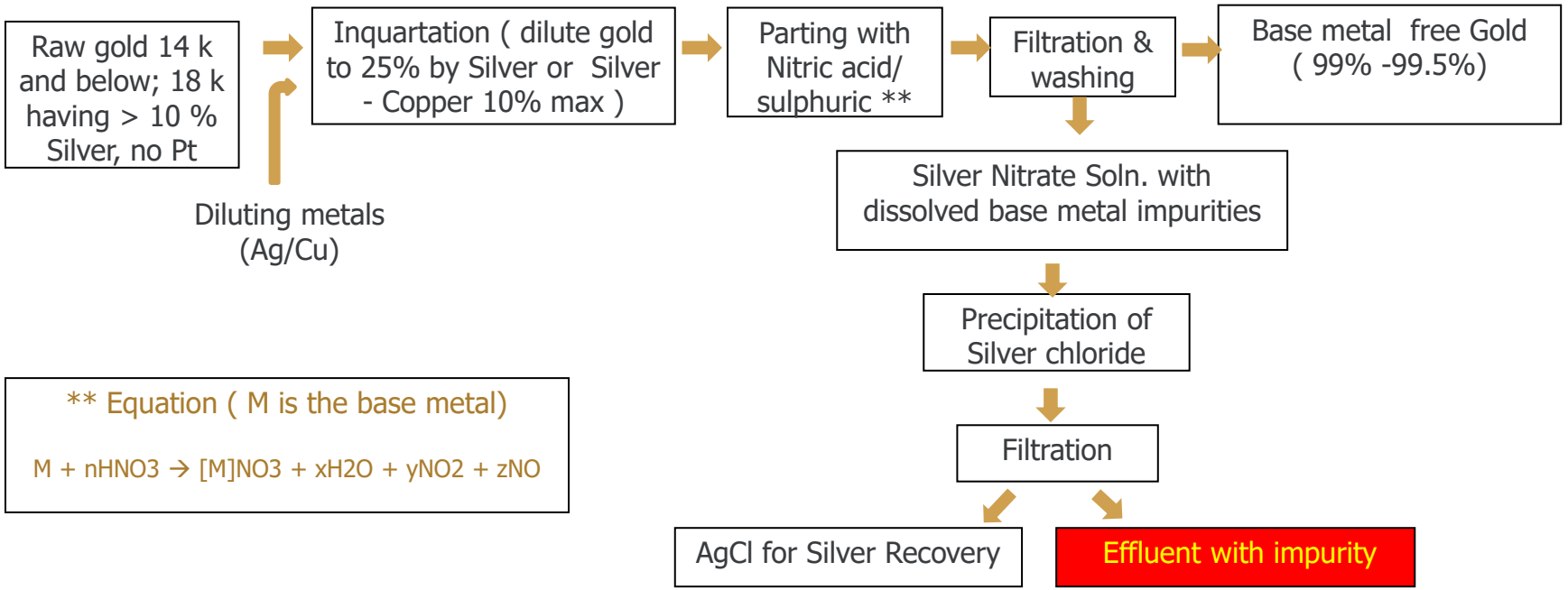


Electric Arc Furnace
(high voltage heating)

Acid less Separation (ALS) - the latest technology



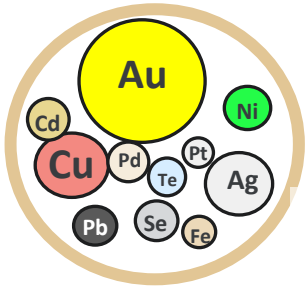
Inquartation and Parting



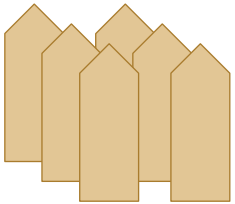
** Equation (M is the base metal)

$M + nHNO_3 \rightarrow [M]NO_3 + xH_2O + yNO_2 + zNO$

ELECTRO REFINING

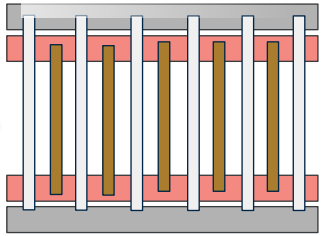


DORE



ANODES

ELECTROLYSIS

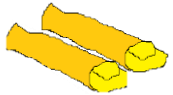


RECYCLING

GRAINS

Melting

SPONGE

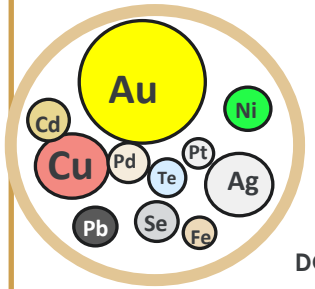


Melting in Tunnel Furnace

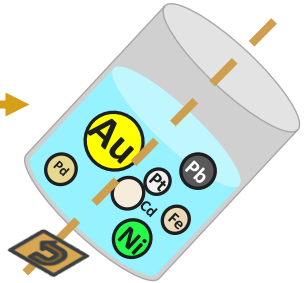
24K Bullion Product

CONSUMED ANODES

CHEMICAL REFINING



DORE



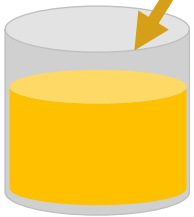
DISSOLVED IN AQUA REGIA

24K GOLD

CEMENTED GOLD

SMBS

PRECIPITATION



Identifying the various hazards

Fumes: Pyrometallurgical process

- Untreated carbon compounds
- Metal oxides
- Heavy metal particles

Fumes by chemical Process

- Untreated acids
- Nox, Sulphur dioxide, Chlorine

Molten Metal

- Hot surfaces
- Unintended metal spurts
- Accidental fires

Effluents: - Chemical process

- High acidic
- Chemical salts of dissolved base metals

Specific causes for fumes

Fumes from Pyrometallurgical processes Generated during heating and melting and may contain untreated carbon compounds, dust particles, metal oxides, heavy metal vapours etc. ; fuel fired furnaces cause more fumes

Fumes from Chemical Refining Generated during acid digestion, gold precipitation, neutralisation and may consist of Nox, Sox , Chlorine , Ammonia vapours etc. formed during reactions :

1. $Au + 3\ HNO_3 + 4\ HCl \rightarrow [AuCl_4]^- + 3\ [NO_2] + [H_3O]^+ + 2\ H_2O$

2. $Au + HNO_3 + 4\ HCl \rightarrow [AuCl_4]^- + [NO] + [H_3O]^{++} H_2O$

3. $HNO_3 + 3HCl \rightarrow NOCl + Cl_2 + 2H_2O$

4. $2\ HAuCl_4 + 2\ NaHSO_3 \rightarrow 2\ Au + 8\ HCl + Na_2SO_4 + SO_2$

5. $3\ SO_2 + 2\ AuCl_3 + 4\ H_2O \rightarrow 3\ H_2SO_4 + 6\ HCl + 2\ Au$

6. $2\ AuCl_3 + 6\ FeSO_4 \dashrightarrow 2\ Au + 2\ Fe_2(SO_4)_3 + Fe_2Cl_4$

Control measures to mitigate hazards from Pyro process fumes

Measures for mitigating risks due to hazards from Fumes from incineration , smelting and melting

- The **suction hoods** should be adequately cover the furnace mouth and ensure that all fumes are trapped.
- The cooled emissions then pass through **series of filters** which trap the air - borne particulates before going to scrubber
- The **scrubber** units spray alkaline solution and neutralize acidity if any in the fumes. The air gets washed as it flows through a column of strainers, becomes almost free from dust particles and exit through its stack.
- Monitoring the quality of the scrub solution as well as avoiding accumulation of sludge in the scrubber tanks is a necessity to ensure efficient functioning of the scrubbing operation.
- Stack emission sampling at frequency defined by CPCB (by authorized lab only) is a mandatory exercise; it will ensure that processes are well controlled and avoid non-compliances during online monitoring by CPCB

Control measures to mitigate hazard from Chemical Fumes

- The **suction hoods** placed close to the reactors and adequately covering the mouth to ensure that all fumes are trapped.
- The cooled emissions are then passed through **series of filters** to trap the air - borne particulates before they are processed in the scrubber.
- The **scrubber** units spray alkaline solution and neutralize acidity if any in the fumes. The air gets washed as it flows through a column of strainers, becomes free from dust particles and exit through the stack.
- Monitoring the quality of the scrub solution as well as avoiding accumulation of sludge in the scrubber tanks to ensure efficient functioning of the scrubbing operation.

Use expert vendor who understands suction calculation and are savvy with pollution norms to design the scrubber for you .

Molten Metal hazards

Molten metal results from any processes in which metals are melted, poured and molded.

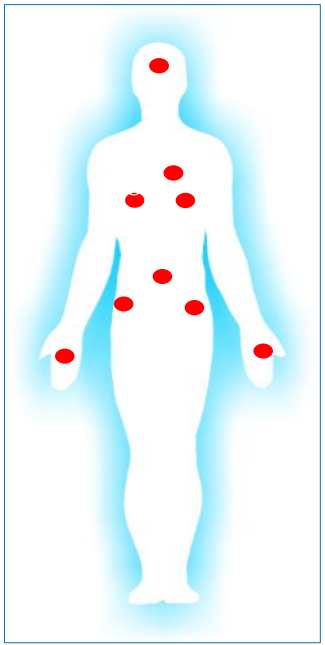
Hazards associated with molten metal include:

- **Heat stress** from exposure of persons to heat, infrared and ultra-violet radiation generated by molten metal.
- **Exposure** to airborne hazardous substances – dusts, fumes, gases and vapour
- **Noise and vibration** generated by mold making machines, grinding and impact tools used to release and dress the metal.
- Mechanical/manual handling of heavy equipment such as molds, ladles, scrap and products
- **Physical injury** and severe first, second and third-degree **burns** from molten metal splash.
- Trips and falls.

Effects of heavy metals on human health

When the gold containing impurities is melted, metals may get carried off as particulate matter and volatile oxides along with the fumes and add to the particulate matter (PM) of the environment.

Element	Behavior in molten condition	Effect on human health
Cadmium	Forms volatile oxide	**Possible Carcinogens** Affects the respiratory and cardiovascular system. Lead has severe effect on renal functions over long exposure; impair body's ability to produce haemoglobin and affect the nervous system too High exposure may lead to collection of fluid in the lungs and bronchitis. Arsenic trioxide may induce, vomiting, diarrhea, gastrointestinal hemorrhage, cerebral edema and hypovolemic shock.
Lead		
Selenium & Tellurium		
Arsenic		
Iron, Nickel, Cobalt and Copper	Are removed as slags; may also be carried as metallic particles in fume.	Metallic fumes if inhaled, may lead to asthma, rhino-conjunctivitis, and dermatitis.
Mercury	Vaporizes as metal at a temperature of 357 ºC	Vapors can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may turn fatal.
Zinc	Produces bright flashes of light and dust cloud .	Over-exposure to zinc oxide fume may cause metal fume fever.



(Table 3) Behavior of elements during melting and casting and their effects on Human being

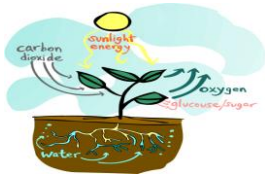
Effects of Lead exposure on human health and control

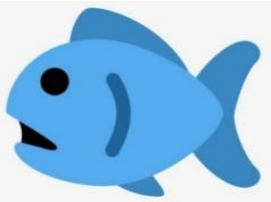
Lead is a ubiquitous metal in the environment, and its adverse effects on human health are well documented.

Lead Exposure	Health Impact	Control measures
• Permissible exposure limit (PEL) of 50 µg/m3 in air	• interacts at multiple cellular sites	• Engineering and Work-Practice Controls eg. mechanical ventilation with quarterly evaluation
	• Adverse effects in multiple body systems, including the nervous, cardiovascular, renal, hematologic, immunologic, and reproductive systems.	• Use of Respirators and PPEs like face shields, vented goggles, and disposable shoe coverlets
		• Housekeeping and Hygiene Facilities and Practices like vacuuming is the preferred method of cleaning. • When vacuuming is shown not to be effective, shoveling or dry or wet sweeping may be used
		• Medical Monitoring-medical surveillance program • Employee Information and Training and Food supplements

Effects of heavy metals on environment

Element	Behavior in molten condition	Effect on Environment
Cadmium	Forms volatile oxide	When absorbed by soil and water sources, may cause growth and functional defects in living organisms.
Lead		When accumulated in organisms, can cause damage to aquatic and terrestrial life forms.
Selenium & Tellurium		Extremely high concentrations can cause reproductive failure and birth defects in animals
Arsenic		Inhibits photosynthesis in plants affecting their growth and survival.
Iron, Nickel, Cobalt and Copper	Are removed as slags; may also be carried as metallic particles in fume.	No specifically mentioned effects.
Mercury	Vaporizes as metal at a temperature of 357 ºC	Equally potent towards aquatic and aerial life forms.
Zinc	Produces bright flashes of light and dust cloud.	Compounds of zinc metal can be toxic to the eco system.





(Table 4) Behavior of elements during melting and casting and their effects on environment

Liquid Effluents from refining process

The chemical refining processes generates liquid effluents which contain impurities removed while processing the gold. The details of the solid and liquid residues/effluents generated from the chemical and electrochemical processes are summarized in the table:

Process	Liquid effluents
Parting	Acidic solutions containing bulk of metal nitrates only
Aqua Regia	Acidic solutions containing bulk of base metal nitrates, chlorides and sulphates.
Electrolytic process	

Details of liquid effluent generated from various process

- The effluent generated from above processes are highly acidic (ph. 1 or less) and also contain large quantity of deleterious metals in form of their soluble salts e.g. chlorides, nitrates, sulphates etc.
- Any solid sludge generated from the treatment of the above effluents is categorized under hazardous waste and requires proper authorizations before attempting its recovery and refining.

Control measures for mitigating hazard from Effluent

Measures for mitigating risk due to hazards from Effluent (Chemical processes)

- The quantity of effluent to be treated should be reduced in planned manner with stoichiometric use of chemicals.
- Recycling of process water with proper study of the water parameters at all stages. .
- A series of processes involving resin treatment, neutralization, flocculation, settling and filtration are adopted prior to sending to ETP which ensures that the impurities and their salt are completely removed, and compliances are duly complied.
- All effluent generated need to be treated before they can be finally discharged as per CPCB norms

Treating all effluent with due diligence is a necessity as the refining process is a hazardous activity .

Government regulations for Effluents (CPCP norms)Vs MMTC-PAMP

Process steps at ETP comprises of equalization, treatment with bases, bacterial treatment, sand and carbon filtration which ensure that the effluent discharge meets norms set by CPCB as mentioned below :

Sr No	Parameter	Unit	Permissible limits for disposal into surface water	MMTC-PAMP disposal into surface water
1	pH	-	5.5 to 9.0	7.65
2	Total suspended solids (TSS)	ppm	<100 ppm	38.1
3	Oil & Grease	ppm	<10 ppm	0.59
4	Biological/biochemical oxygen demand (BOD)	ppm	<30 ppm	22.3
5	Chemical oxygen demand (COD)	ppm	<250 ppm	79.6

(Table 7) CPCB requirements for effluents disposal

Live monitoring of data and its transmission to CPCB server has been made mandatory and needs to be complied in order to ensure zero non-compliance.

MMTC PAMP Environmental Performance in Past Two Years

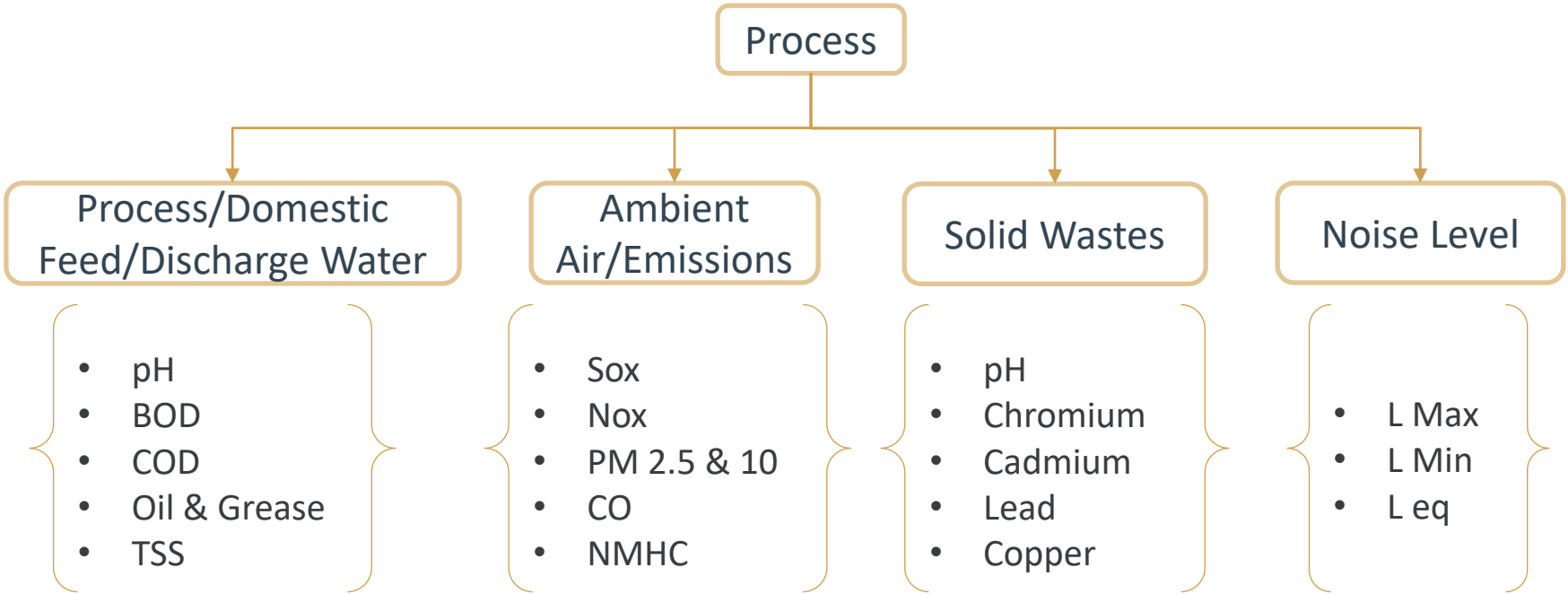
Government regulations (CPCB norms)

Group	Description	Frequency as per HSPCB	Parameters	Limits	Units
1	Analysis of Inlet Effluent Water of STP	Quarterly	PH	_	_
			Chemical Oxygen Demand (COD)	_	mg/l
			Biochemical Oxygen Demand (BOD)	_	mg/l
			Total Suspended Solids (TSS)	_	mg/l
			Oil & Grease (O & G)	_	mg/l
2	Analysis of Inlet Effluent water of ETP	Quarterly	PH	_	_
			Chemical Oxygen Demand (COD)	_	mg/l
			Biochemical Oxygen Demand (BOD)	_	mg/l
			Total Suspended Solids (TSS)	_	mg/l
			Oil & Grease (O & G)	_	mg/l
3	Analysis of Outlet Effluent water of ETP	Monthly	PH	5.5 - 9.0	_
			Chemical Oxygen Demand (COD)	250	mg/l
			Biochemical Oxygen Demand (BOD)	30	mg/l
			Total Suspended Solids (TSS)	100	mg/l
			Oil & Grease (O & G)	10	mg/l
4	Analysis of Outlet Effluent water of STP	Monthly	PH	5.5-9.0	_
			Chemical Oxygen Demand (COD)	250	mg/l
			Biochemical Oxygen Demand (BOD)	30	mg/l
			Total Suspended Solids (TSS)	100	mg/l
			Oil & Grease (O & G)	10	mg/l
5	Analysis of STP Sludge	Quarterly	PH (at 25 C)	5.5-8.5	_
			Chromium as Cr	50	mg/ kg
			Copper as Cu	300	mg/ kg
			Cadmium as Cd	5	mg/ kg
			Lead as Pb	100	mg/ kg
6	Analysis of ETP Sludge	Quarterly	PH (at 25 C)	5.5-8.5	_
			Chromium as Cr	50	mg/ kg
			Copper as Cu	300	mg/ kg
			Cadmium as Cd	5	mg/ kg
			Lead as Pb	100	mg/ kg
7	Analysis of Drinking Water (As per ISO:10500) Plant	Half Yearly	PH	6.5-8.5	_
			Chloride	250	mg/l
			Total Hardness as CaCO3	200	mg/l
			Sulphates as SO4	200	mg/l
			Total Dissolved Solids (TDS)	500	mg/l
8	Analysis of Drinking Water (As per ISO:10500) Kitchen	Half Yearly	PH	6.5-8.5	_
			Chloride	250	mg/l
			Total Hardness as CaCO3	200	mg/l
			Sulphates as SO4	200	mg/l
			Total Dissolved Solids (TDS)	500	mg/l

Government regulations (CPCP norms)

Group	Description	Frequency as per HSPCB	Parameters	Limits	Units
9	Borewell-1 Water Analysis (As per ISO-10500)	Half Yearly	PH	6.5-8.5	_
			Chloride	1000	mg/l
			Total Hardness as CaCO3	600	mg/l
			Sulphates as SO4	400	mg/l
			Total Dissolved Solids (TDS)	2000	mg/l
10	Ambient Air Monitoring (Utilty_VCB Room/ 24 Hours)	Half Yearly	Particulate Matter (PM 2.5)	60	Microgram / m3
			Particulate Matter (PM 10)	100	Microgram / m3
			Nitrogen Di Oxide (NO2)	80	Microgram / m3
			Sulphur Di Oxide (SO2)	80	Microgram / m3
			Carbon Monoxide (CO)	4	mg/m3
11	Stack Emission Monitoring (Silver & Gold Scrubber)	Half Yearly	Particulate Matter (PM)	_	mg /Nm3
			Oxides of Nitrogen (NOx)	_	mg /Nm3
			Sulphur Di Oxide (SO2)	_	mg /Nm3
			Carbon Monoxide (CO)	_	mg /Nm3
12	Stack Emission Monitoring (DG Set-1_1500 KVA)	Half Yearly	Particulate Matter (PM)	75	mg /Nm3
			Oxides of Nitrogen (NOx)	710	PPMV
			Sulphur Di Oxide (SO2)	_	mg /Nm3
			Carbon Monoxide (CO)	150	mg /Nm3
			Non-Methane Hydrocarbons (NMHC)	100	mg /Nm3
13	Work Zone Noise Monitoring (DG Set-1 for 30 Minutes)	Half Yearly	Leq (Open Acoustic Enclosure)	_	dB (A)
			Leq (Closed Acoustic Enclosure)	75	dB (A)
			Insertion Loss	_	_
14	Ambient Noise level Monitoring (Kitchen Corner/ 24 Hours)	Half Yearly	Leq (Lequivalent)		dB (A)
			Limits (Day Time) (6 :00 AM to 10:00 PM)	75	dB (A)
			Limits (Nighttime) (10 : 00 PM to 6:00 AM)	70	dB (A)
15	Environmental Status Report	Yearly	Detail report on water consumption, power consumption overall production, waste generated		
16	Annual Audit Report(by external agency)	Yearly	Annual audit		

Government regulations for Industrial Processes (CPCB norms)

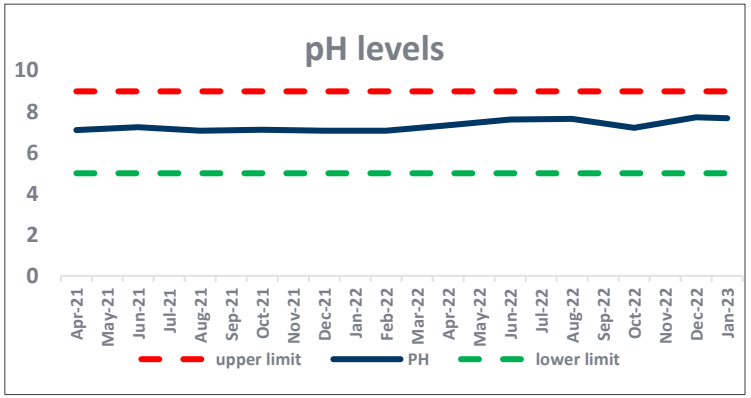


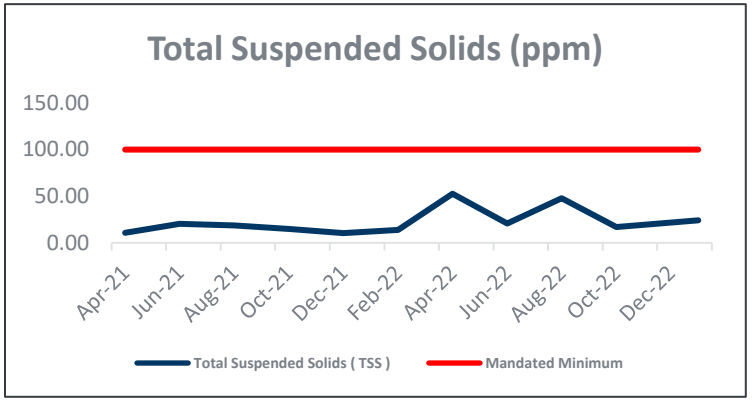
Government regulations for discharged air quality(CPCB norms)

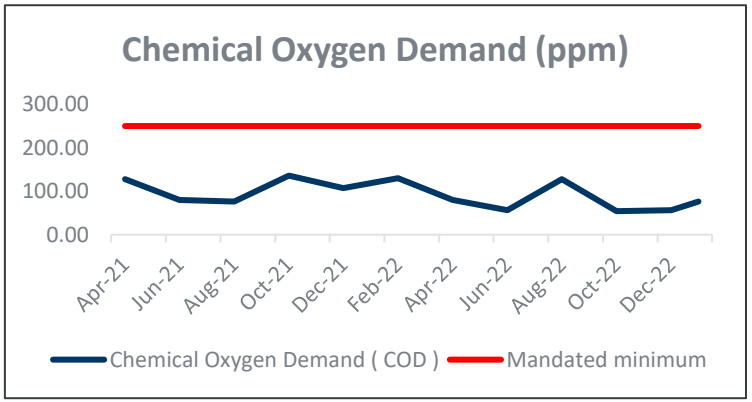
Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and Other Areas	Ecologically Sensitive Area (notified by Central Government)
Sulphur Dioxide (SO2), µg/m3	Annual* 24 hours**	50 - 80	20 - 80
Nitrogen Dioxide (NO2), µg/m3	Annual* 24 hours**	40 -80	30 - 80
Particulate Matter (size less than 10 µm) or PM10 µg/m3	Annual* 24 hours**	60- 100	60 - 100
Particulate Matter (size less than 2.5 µm) or PM2.5 µg/m3	Annual* 24 hours**	40- 60	40 - 60
Lead (Pb) µg/m3	Annual* 24 hours**	0.50 - 1.0	0.50 - 1.0
Arsenic (As), ng/m3	Annual*	6	60
Nickel (Ni), ng/m3	Annual*	20	20

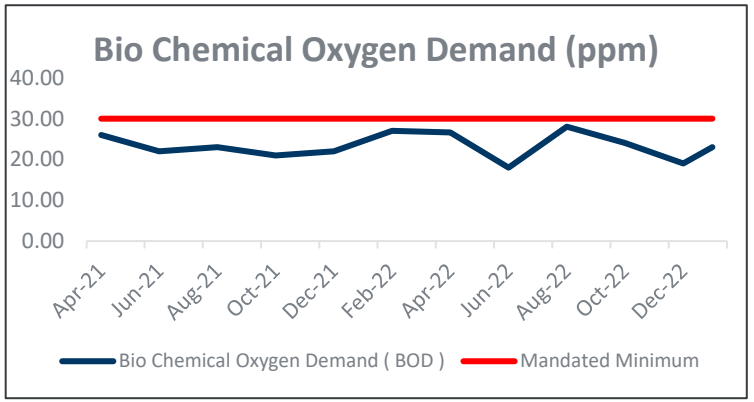
*** Annual arithmetic means of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.**
**** 24 hourly or 8 hourly or 1 hourly monitored value, as applicable, shall be complied with 98% of the time, they may exceed the limits but not on two consecutive days of monitoring.**
Source: National Ambient Air Quality Standards, Central Pollution Control Board Notification in the Gazette of India, Extraordinary, New Delhi, 18th November, 2009

1. Discharge Water

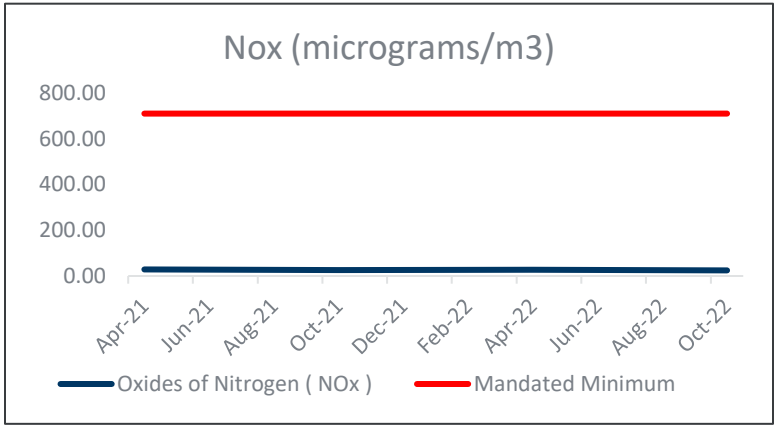


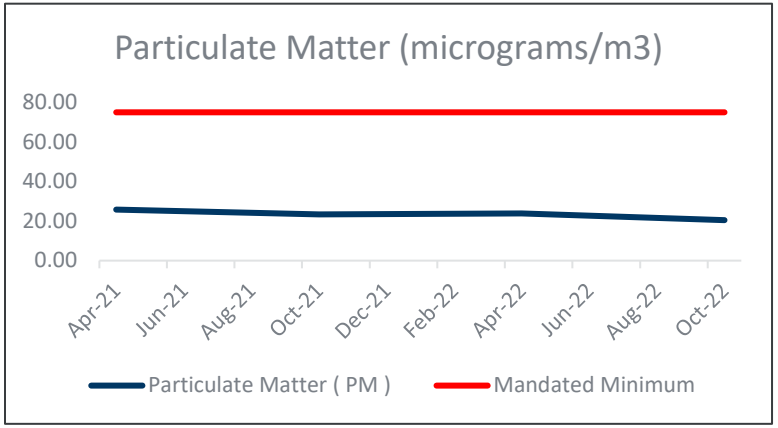


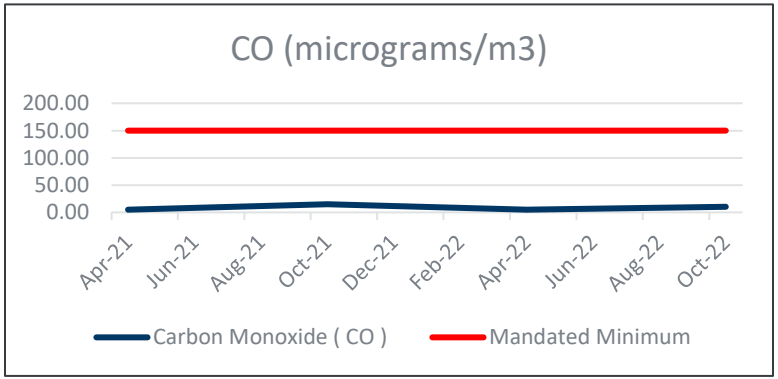


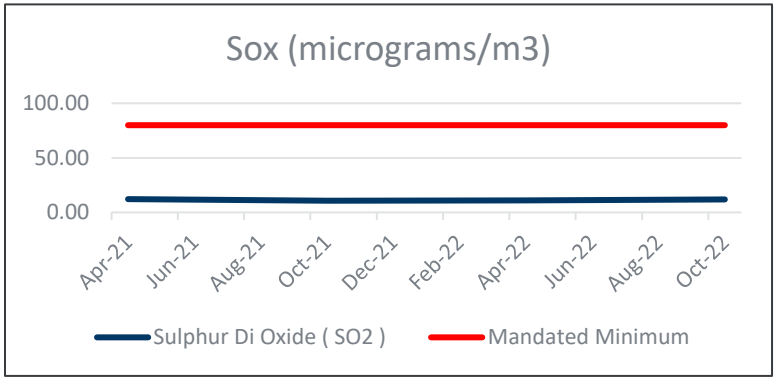


2. Emissions

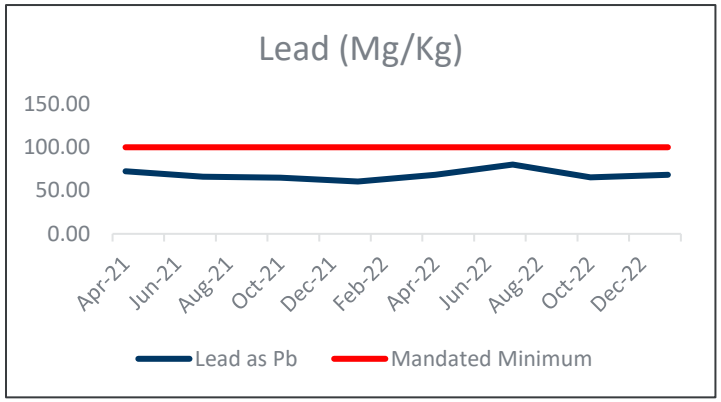

Nox (micrograms/m3)
800.00
600.00
400.00
200.00
0.00
Apr-21
Jun-21
Aug-21
Oct-21
Dec-21
Feb-22
Apr-22
Jun-22
Aug-22
Oct-22
Oxides of Nitrogen (NOx)
Mandated Minimum

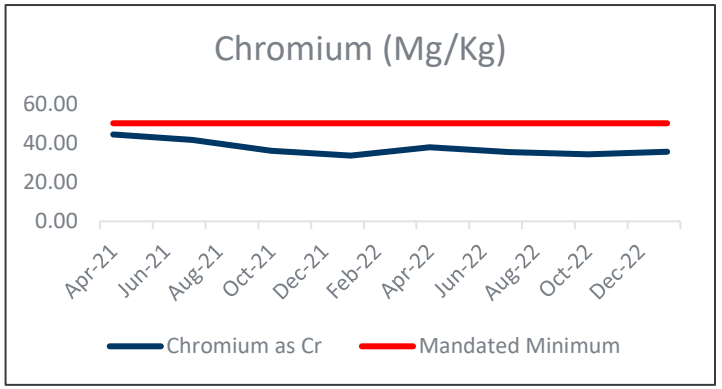

Particulate Matter (micrograms/m3)
80.00
60.00
40.00
20.00
0.00
Apr-21
Jun-21
Aug-21
Oct-21
Dec-21
Feb-22
Apr-22
Jun-22
Aug-22
Oct-22
Particulate Matter (PM)
Mandated Minimum

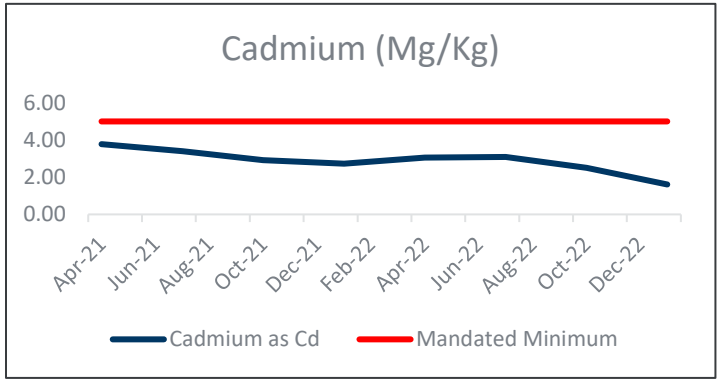

CO (micrograms/m3)
200.00
150.00
100.00
50.00
0.00
Apr-21
Jun-21
Aug-21
Oct-21
Dec-21
Feb-22
Apr-22
Jun-22
Aug-22
Oct-22
Carbon Monoxide (CO)
Mandated Minimum

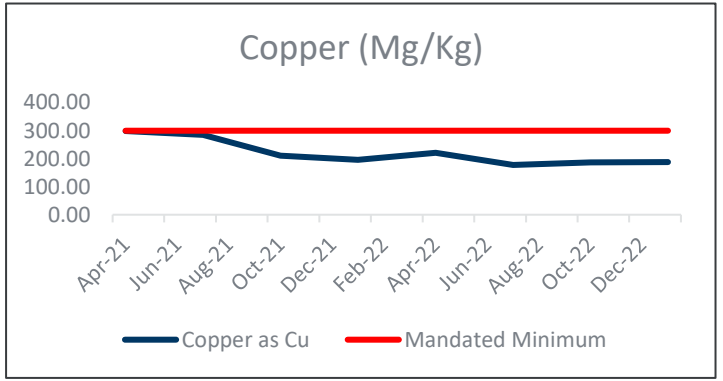

Sox (micrograms/m3)
100.00
50.00
0.00
Apr-21
Jun-21
Aug-21
Oct-21
Dec-21
Feb-22
Apr-22
Jun-22
Aug-22
Oct-22
Sulphur Di Oxide (SO2)
Mandated Minimum

3. Solid Wastes/Sludges

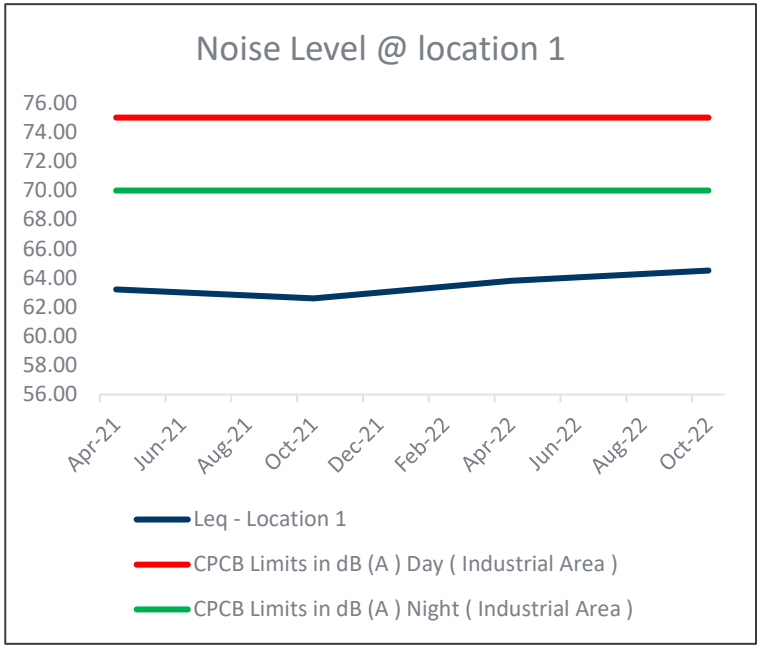


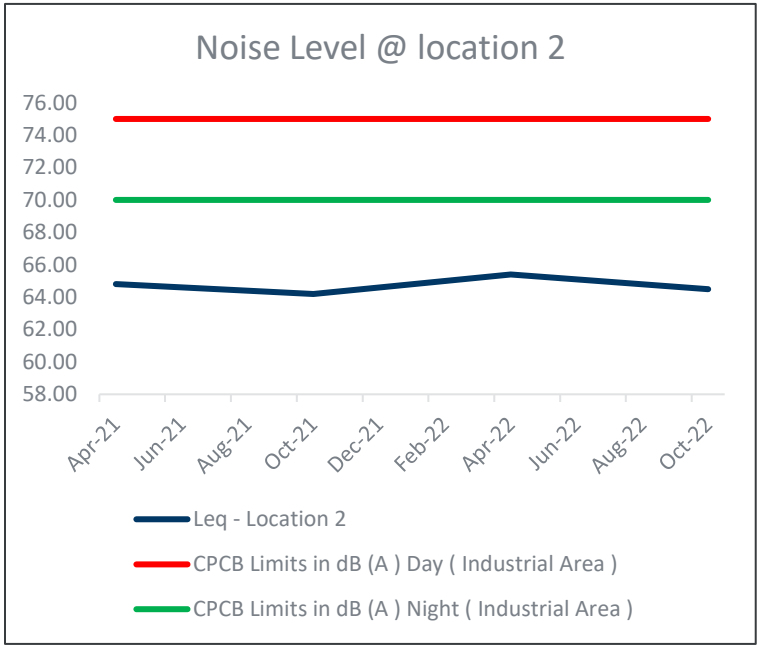






4. Ambient Noise Levels





Refinery Hazards

Sl. No.	Hazards	Cause	Risk	Level	Existing Controls	Additional Controls	Final Risk Score	Final Level
1	Fumes	NOx fumes	Skin irritants, Asphyxiation & Corrosives	Extreme Risk	Air ventilation, Scrubber (with UPS backup), Nox dector, PPE's	Periodic cleaning of scrubber, pH monitoring, Additional scrubber connected	10	Low Risk
		Sox fumes	Respiratory system, particularly lung function, and can irritate the eyes	High Risk	Air ventilation, Scrubber (with UPS backup), PPE's	Perodic cleaning of scrubber, pH monitoring, Additional scrubber connected	8	Low Risk
		Toxic smoke	Respiratory irritation and shortness of breath and can worsen medical conditions.	High Risk	Air ventilation, Scrubber (with UPS back up) & Jet bag filter, PPE's & Medical checkup	pH monitoring before charging material for melting, Furnace covering during melting.	10	Low Risk
2	Molten metal	Accidental spurts	3rd degree burns	High Risk	Usage of moisture free accessories	Fire resistant aprons, thermal gloves and other appropriate PPE's	10	Low Risk
3	Effluent	Acid burn	Redness, irritation or burning at the site of contact.	Low Risk	Shower available at workplace, Medicine available in first aid box, PPE's	Periodic checking of first aid box & Shower.	6	Low Risk
4	Physical injuries	Handling of sharp/heavy loads	Cuts/Hits caused during harvesting/casting/metal transfer	High Risk	Usage of material moving trolleys/container trays	Operator training, usage of appropriate PPEs	6	Low Risk
5	Slips and trips	Spillage of solid lubricants (graphite) on the floor	Nasty falls that may lead to severe injuries	High Risk	Frequent cleaning of the floor	Usage of anti skid tapes to make the possible area safe to operate.	10	Low Risk

Score	Action
20 to 25	Extreme Risk: Immediate action required to mitigate the risk.
16 to 19	High Risk: Action should be taken to compensate for the risk.
11 to 15	Moderate Risk: Action should be taken to monitor the risk.
5 to 10	Low Risk: Routine acceptance of the risk.

Refinery Hazards

Sl. No.	Hazards	Cause	Risk	Level	Existing Controls	Additional Controls	Final Risk Score	Final Level
1	Fire hazards	Electrical fire & Flames	Burn, Risk of life & loss of property	Moderate Risk	Fire extinguisher, Periodic checking of LPG leakage, BA Set	Preventive maintenance	10	Low Risk
2	Physical hazards	Unsafe conditions (Slips, trips, falls, noise, heat & cold) & Safety ignorance.	physical discomfort, pain, injury, illness.	Low Risk	Using anti-skid tape at high-risk area, frequent floor cleaning, Air Ventilation, PPE's	Monthly Safety training & Awareness	8	Low Risk
3	Ergonomic hazards	Unsafe Act (repetition, awkward posture, forceful motion, stationary position, direct pressure & work stress)	Workplace situations that cause wear and tear on the body and can cause of injury.	Low Risk	Using battery operated truck & trolley.	Awareness trainings	8	Low Risk
4	Workplace hazards	workload, lack of control & overworking	Stress, fatigue, error & loss of business.	High Risk	Working hours monitoring, Leave planning, SA-8000 certified	Week off planning before 10 days of continous working.	6	Low Risk
5	Biological hazards	Bacteria & viruses	Health effects ranging from skin irritation, allergies, tetanus, respiratory infections.	Moderate Risk	Follow up of health advisory, Medical checkup.	Awareness trainings	12	Low Risk

Score	Action
20 to 25	Extreme Risk: Immediate action required to mitigate the risk.
16 to 19	High Risk: Action should be taken to compensate for the risk.
11 to 15	Moderate Risk: Action should be taken to monitor the risk.
5 to 10	Low Risk: Routine acceptance of the risk.

Conclusion

Gold recovery and refining consists of set of complex steps involving application of high heat and hazardous chemicals

Each technique described in slides above deals with hazardous chemical and by-products during the entire cycle . The risks posed by those hazards have severe impact on human being and ecosystem if not mitigated with due diligence.

OSHAS guidelines of HIRA (hazard identification and risk assessment) are becoming increasingly stringent to ensure safety to our ecosystem. Hence, all refinery needs to adopt a strategy which aims to mitigate the risks fully and provide convincing evidence in a transparent manner during any audit.

Regular safety audits , proactive monitoring of specified parameters , use of correct PPE, health examination of working personnel are some of the key points to be monitored regularly.

For the sake of business continuity, refineries who have their inhouse facility may thus require a re-evaluation of their existing capabilities and upgrade them in order to comply with set norms.

THANK YOU