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CADMIUM

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GOVERNMENT OF INDIA
MINISTRY OF MINES
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3 Cadmium

Cadmium is a soft, bluish-white metal of low melting point which is present generally in zinc ore deposits as greenockite (CdS). The principal source of cadmium is zinc ore, sphalerite. Other sulphides and sulphosalts may also carry small amounts of the metal.

In India, cadmium is recovered as a by-product during zinc smelting and refining. The concentration of cadmium in sphalerite, the principal ore of zinc, ranges from 0.03 to 9.0 wt%.

INDUSTRY

The total annual installed capacity for recovering cadmium was 913 tpy of which HZL accounted for 833 tpy capacity. Binani Zinc Ltd (Edayar Zinc Ltd) reported the remaining 80 tpy capacity (Table-1). HZL produces cadmium of high quality in its zinc smelters which is casted in the form of pencils weighing from 250 g to 500 g. The purity is 99.95% Cd (max.) at Debari; 99.97% Cd (max.) at Vizag and 99.99% Cd (min.) at Chanderiya plants. HZL has plans to conduct R&D for production of high purity cadmium. High purity cadmium is typically used for nuclear shielding applications. As per HZL AR 2019-20, cadmium production plant with capacity to produce 2,600 tonnes per annum of cadmium from smelter process residues is in the installation phase.

Table – 1 : Installed Capacity for Recovery of Cadmium

Unit	Location	Installed capacity (tpy)
Total		**913**
1. HZL, Debari Zinc Smelter	Debari, Distt. Udaipur, Rajasthan.	250
2. HZL,* Vizag Zinc Smelter	Visakhapatnam, Andhra Pradesh.	115
3. HZL, Chanderiya Lead-Zinc Smelter	Chanderiya, Distt. Chittorgarh, Rajasthan.	468
4. Binani Zinc Ltd** (Edayar Zinc Ltd)	Binanipuram, Distt. Ernakulam, Kerala.	80

** Operation suspended since 2002*
*** Operation suspended since April-2014*

USES

Cadmium is used to control the fissionable elements in nuclear reactors. Along with nickel, it is used in electrical storage/rechargeable batteries. Cadmium-based bearing alloys are used in high-speed internal combustion engines. Copper-cadmium alloys possess high strength, high conductivity and high resistance to abrasion, and therefore, the alloys are used in electric transmission wires. The main use of cadmium is in electroplating where it can be applied as a very thin coating to protect iron, steel, copper alloys and other metals and alloys from corrosion. Cadmium sulphide forms brilliant golden yellow, orange-red or reddish brown pigments used in paint, enamel, soap, rubber, glass and ceramic glazes. Some cadmium salts are also used in photographic films and in lithography. Cadmium coated products are preferred for a wide range of critical and safety-related applications in the aerospace, electrical, defence, mining, nuclear fission, television and offshore industries. Cadmium plating is used mainly in the aviation and aerospace industries to protect fastners exposed to hostile environments.

PRODUCTION & PRICES

Production of cadmium is generally reported as a by-product of zinc smelting and is nil during both the year i.e. 2018-19 & 2019-20 (Tables-2). The entire production in 2017-18 was reported from the State of Rajasthan. The foreign market prices of cadmium are furnished in the General Review on "Prices".

Table – 2 : Production of Cadmium 2017-18 to 2019-20 (By States)

(Quantity in tonnes; Value in ₹'000)

State	2017-18		2018-19		2019-20 (P)	
	Qty	Value	Qty	Value	Qty	Value
India	47	5685	-	-	-	-
Rajasthan	47	5685	-	-	-	-

RECYCLING

National Waste and Recycling Associations (NWRAs) have been created around the world to promote the collection and recycling of all batteries, both from the general public and industrial consumers. Nickel-cadmium batteries which account for about three-fourths of the cadmium consumed, are virtually 100 per cent recyclable once they have been collected. The recovery of cadmium from cadmium products through recycing not only ensures that cadmium be kept out of the waste stream and out of the environment, but also that there is consumption of this valuable natural resource as well. Exide Industries Ltd India's largest manufacturer of lead-acid storage batteries and power storage solutions provider, has invested in building a battery recycling plant at Haldia (West Bengal) and has plans to expand its existing facility to maunfacture Nickel-Cadmium batteries. The plant in Haldia will have a monthly capacity of 15,000 tonnes, making it the country's largest lead recycling facility. The project would give the company's recycling capacity a tremendous boost. It already operates two lead recycling plants near Pune and Bengaluru, which have a combined monthly capacity of 11,500 tonnes of recycled lead. The expansion project in Haldia is aimed at procucing high-end Nickel-Cadmium batteries in technical collaboration with Furukawa of Japan. "These batteries find applications in bullet trains, metro rail and other critical installations. This plant will also produce lead-acid batteries".

As per JMK Research estimates, the lithium-ion battery market in India is expected to increase from 2.9 GWh in 2018 to about 132 GWh by 2030 (CAGR of 35.5%). Raasi Solar has announced plans to set up a 300MW plant focussing on lithium battery recycling along with battery assembling and cell manufacturing facility.

SUBSTITUTES

Suitable replacements of cadmium in all uses, especially in pigments and plating are being contemplated and enforced owing to the pollution hazards associated with the use of cadmium. Ni-Cd batteries, in some applications, are replaced with lead-acid, fuel cells lithium ion and nickel metal hydride batteries. However, higher costs of these substitutes restrict their uses. Cadmium in plating applications can be substituted by coatings of zinc or vapour-deposited aluminium. Cerium sulphide is used as a replacement for cadmium pigments mostly for plastics. Cadmium telluride (CdTe) flexible thin film solar cells are an alternative to traditional crystalline silicon solar cells and are suitable for commercial roof top applications and large-scale ground mounted utility systems. CdTe photovoltaic cells are potentially safe, environment-friendly application for cadmium.

In India, cadmium is consumed in industries like paint, glass and chemical.

HEALTH AND SAFETY

Cadmium in all its chemical forms is considered highly toxic to living species as it does not decompose and if ingested through food, water and air it dose not get excreted easily. It is both bioaccumulated and biomagnified. Ingested cadmium accumulates in liver, kidney, pancreas and thyroid. Excessive exposure to cadmium has been linked with respiratory insufficiency (via occupational exposure) and renal disturbance (via environmental and occupational exposure). Cadmium has also been implicated in the development of cancer of various types.

During the last decade, regulatory pressure to reduce or even eliminate the use of cadmium has gained momentum in many developed countries. The world recommended target guidelines for cadmium as a residual heavy metal below which no major risk is expected which could have significant or adverse impact on aquatic biota or human use is 0.1 mg/l. In the USA, Federal and State agencies regulate cadmium content in the environment. Cadmium present in CRT screens, printer inks, toners, etc. is known to cause health hazards affecting the kidneys and causing flue like symptoms and muscular pain. In India, the Silver Jewellery Industry is an important cadmium consuming industry. Silver mixed with cadmium is used in the making of silver jewellery.

WORLD REVIEW

Cadmium is generally recovered from zinc ores and concentrates. Sphalerite, the most economically significant zinc ore mineral, commonly contains minor amounts of cadmium, which shares certain similar chemical properties with zinc and often

substitutes for zinc in the sphalerite crystal lattice. The cadmium mineral greenockite is frequently associated with weathered sphalerite and wurzite. Zinc-bearing coals of the Central United States and Carboniferous Age coals of other countries also contain large subeconomic resources of cadmium. Zinc-to-cadmium ratios in typical zinc ores range from 200:1 to 400:1. Quantitative estimates of reserves are not available. Cadmium content of typical zinc ore averages about 0.03%.

The world production of cadmium was estimated at about 27,500 tonnes in 2019. China (37%), Rep. of Korea (18%) and Japan, Canada & Russia (7% each), remaining share was contributed by Kazakhstan, Netherlands, Mexico, Peru and other countries. Quantitative estimates of reserves are not available. the cadmium content of typical zinc ores averages about 0.03%. Most of the world's primary cadmium is produced mainly in China, Republic of Korea, Japan, Canada, Kazakhstan, Mexico, Russia and Peru. As per Mineral Commodity Summaries, 2021 of USGS Report, the world refinery production of cadmium was estimated at 24,400 & 23,000 tonnes in 2019 & 2020, respectively.

World's secondary cadmium production accounted for 20% of the total metal production. Most secondary metal is produced at NiCd battery recycling facilities in Asia, Europe and the United States. China, Belgium and Japan are by far the world's largest consumers of cadmium. The world production of cadmium during 2017 to 2019 by principal countries is furnished in Table-3. To provide a generalised view of the development in various countries, the countrywise description sourced from latest available publication of Minerals Yearbook 'USGS' 2016 is furnished as below.

Australia

Nyrstar increased crude cadmium production capacity at its lead smelter in Port Pirie, South Australia. The capacity expansion was part of a larger project at Port Pirie to enable the smelter to treat a wider range of feedstock and to update the facility's environmental controls. The new capacity was commissioned in September. Port Pirie produced a crude cadmium product, which must be further refined to produce pure cadmium metal. Nyrstar's zinc smelter in Hobart, Tasmania was the sole producer of refined cadmium metal in Australia in 2017.

Table – 3 : World Production of Cadmium (By Principal Countries)

(In tonnes)

Country	2017	2018	2019
World: Total (rounded)	**24900**	**28300**	**27500**
China	8411	10349	10300[e]
Korea, Rep. of	4000	4905	4900[e]
Japan	2310	2108	1900[e]
Canada[a]	1802	1857	1803
Russia[e]	1700	1800	1800
Kazakhstan[e]	1500	1500	1400
Netherlands[e]	620	1100	1100
Mexico	1142	1307	952
Peru	797	765	772
Other countries	2651	2642	2599

Source: *BGS World Mineral Production, 2015-19,*
a) including cadmium sponge and/or secondary metal.

FOREIGN TRADE

Exports

Exports of Cadmium increased drastically by 98% to 251 tonnes during 2019-20 from 127 tonnes in the previous year. Exports were mainly to China (57%), Bangladesh (38%) and Pakistan (4%). Similarly, exports of cadmium (including waste & scrap) also incrteased drastically by 85% to 268 tonnes during 2019-20 from that of 145 tonnes in the previous year.

On the other hand exports of cadmium & alloys decreased substantially by 24% to 93 tonnes during 2019-20 as against 122 tonnes in the previous year, while exports of cadmium & scrap increased marginally by 6% to 18 tonnes in 2019-20 against 17 tonnes in 2018-19. Exports of cadmium unwrought and powders increased by huge quantity to 156 tonnes during 2019-20 as compared to 6 tonnes in the previous year. Export were mainly to China (92%), Pakistan (6%) and Bangladesh (2%) (Tables-4 to 8).

Imports

Like exports imports of cadmium also increased by 16% to 7,999 tonnes in 2019-20 from 6,903 tonnes in the previous year. Imports of cadmium was mainly from China (25%), UAE (12%), Rep.of Korea (11%), Japan (9%), Peru & Maxico (8% each), Hong Kong (7%), UK (4%) and Russia & Belgium (3% each). Imports of cadmium (including waste & scrap) increased by 8% to 9,639 tonnes in 2019-20 from 8,898 tonnes in the year 2018-19. The imports also comprised 7,995 tonnes of unwrought & powders and 1,640 tonnes of cadmium & scrap besides 4 tonnes of cadmium & alloys in 2019-20 (Tables- 9 to 13).

Table – 4: Exports of Cadmium (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**127**	**17507**	**251**	**33438**
China	-	-	143	16973
Bangladesh	114	15106	96	12814
Pakistan	13	1816	10	2195
Australia	-	-	++	1037
UAE	++	63	1	227
Yemen	-	-	++	165
Nepal	1	91	++	19
Sri Lanka	-	-	++	7
Macedonia	-	-	++	1
Mexico	++	247	-	-
Other countries	++	183	-	-

Figures rounded off

Table – 5: Exports of Cadmium (Including Waste & Scrap) (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**145**	**20128**	**268**	**35679**
China	-	-	143	16973
Bangladesh	124	16564	114	15036
Pakistan	19	2767	10	2195
Australia	-	-	++	1037
UAE	++	63	1	243
Yemen	-	-	++	165
Nepal	1	91	++	19
Sri Lanka	-	-	++	7
Bhutan	++	9	++	2
Qatar	1	142	++	1
Other countries	1	492	++	1

Figures rounded off

Table – 6: Exports of Cadmium & Alloys (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**122**	**16424**	**93**	**13439**
Bangladesh	112	14801	92	12214
Australia	-	-	++	1037
UAE	-	-	++	143
Yemen	-	-	++	37
Sri Lanka	-	-	++	7
Macedonia	-	-	++	1
Mexico	++	247	-	-
Nepal	1	71	-	-
Pakistan	9	1278	-	-
Qatar	++	5	-	-
Other countries	++	22	-	-

Figures rounded off

Table – 7: Exports of Cadmium & Scrap (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**17**	**2621**	**18**	**2241**
Bangladesh	10	1457	18	2222
UAE	-	-	++	16
Bhutan	++	9	++	2
Qatar	1	138	++	1
UK	-	-	++	++
Iraq	++	14	-	-
Myanmar	++	20	-	-
Oman	++	30	-	-
Pakistan	7	951	-	-
Philippines	++	2	-	-

Figures rounded off

Table – 8: Exports of Cadmium: Unwrought, Powders (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**6**	**1083**	**156**	**19774**
China	-	-	143	16973
Pakistan	4	538	10	2195
Bangladesh	2	306	3	376
Yemen	-	-	++	128
UAE	++	63	++	84
Nepal	++	21	++	19
Myanmar	++	37	-	-
Saudi Arabia	++	119	-	-

Figures rounded off

Table – 9: Imports of Cadmium (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**6903**	**1347546**	**7999**	**1490921**
China	1470	292247	1988	375093
Korea, Rep.of	822	173400	909	177007
UAE	356	69829	955	164528
Japan	963	198611	747	141736
Peru	480	93742	615	112535
Mexico	602	111648	620	112366
Hong Kong	417	73622	592	109667
UK	328	66678	291	56250
Russia	188	37782	275	53771
Belgium	312	60712	224	43857
Other countries	965	169274	784	144111

Figures rounded off

Table – 10: Imports of Cadmium (Including Waste & Scrap) (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**8898**	**1742740**	**9639**	**1787948**
China	1955	384891	2401	452322
Korea, Rep.of	1302	273225	1262	246354
Japan	1577	319133	1284	242993
UAE	356	69829	955	164528
Peru	520	101289	675	124280
Hong Kong	417	73622	654	117207
Mexico	663	123403	620	112366
UK	328	66678	291	56250
Russia	308	63717	275	53771
Belgium	312	60712	224	43857
Other countries	1159	206241	1000	174019

Figures rounded off

Table – 11: Imports of Cadmium & Alloys (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**43**	**4409**	**4**	**1158**
Korea, Rep. of	43	4211	4	642
Hong Kong	-	-	++	295
USA	++	109	++	170
Germany	++	48	++	50
UK	-	-	++	2
Canada	++	42	-	-

Figures rounded off

Table – 12: Imports of Cadmium: Unwrought, Powders (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**6860**	**1343137**	**7995**	**1489763**
China	1427	288036	1984	374451
Korea, Rep. of	822	173400	909	177007
UAE	356	69829	955	164528
Japan	963	198611	747	141736
Peru	480	93742	615	112535
Mexico	602	111648	620	112366
Hong Kong	417	73622	592	109372
UK	328	66678	291	56248
Russia	188	37782	275	53771
Belgium	312	60712	224	43857
Other countries	965	169076	784	143891

Figures rounded off

Table – 13: Imports of Cadmium & Scrap (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**1994**	**395195**	**1640**	**297026**
Japan	614	120522	537	101258
China	485	92644	413	77230
Korea, Rep. of	480	99825	353	69347
Brazil	56	7288	147	13434
Peru	40	7547	60	11745
Kazakhstan	-	-	49	10260
Hong Kong	-	-	62	7540
USA	18	3232	20	4331
Canada	-	-	++	1882
Russia	120	25935	-	-
Other countries	181	38202	-	-

Figures rounded off

FUTURE OUTLOOK

The world cadmium market based on the world production of cadmium does indicate a fluctuating trend. While the primary cadmium supply is on decrease, there is a modest rise in production through recycling. Though cadmium consumption in various applications is clamoured with concerns over its toxicity and hazardous effect on human health and environment, the production of cadmium as a by-product will, however, continue as long as lead and zinc are produced.

The demand for cadmium is increasing owing to several new market opportunities for NiCd batteries, particularly, in industrial applications. NiCd battery had been favoured for use in less expensive consumer appliances and electronics owing to their cost advantage over other battery chemistries. During the past few years, lithium-ion batteries have significantly replaced NiCd batteries in some low-cost electronics and substitution is expected to continue as the manufacturing cost of lithium-ion batteries decreases and their electrical storage capacity increases.

NiCd batteries, however, are expected to continue to be used in certain industrial applications because of their superior reliabilility and stability compared with the other rechargeable battery technologies. NiCd batteries power some battery-powered electric vehicles and are also used in a limited number of hybrid electric vehicles. NiCd batteries are also used as buffers in transportable/renewable hybrid-power systems developed to generate electricity in remote locations and in underdeveloped regions. Industrial-sized NiCd batteries potentially could be used to store energy produced by certain on-grid solar or wind systems. Excess energy generated during periods of low electricity demand could be stored in batteries, from which it would later be dispatched during periods of high electricity demand. NiCd may be a favoured battery chemistry for this use owing to its stability in offshore and harsh weather environments. NiCd battery is used in electrical vehicles albeit in limited number in hybrid electrical vehicles and has been making important contribution to the development of the electric car market in Europe.

Candium pigments and stabilisers are important additives in certain specialised plastic, glasses, ceramics and enamels which enable to achieve bright colours along with long service life, even in very demanding applications. It should also be emphasised that cadmium in these applications is in a chemically very stable, highly insoluble form and is embedded in the product matrix.