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Mining of Gold from E-waste and saving it for Future Demand: A Review

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ABSTRACT: Worldwide for manufacturing high-tech products like PCs, cell phones, tablet computers and other electronic and electrical devices, 320 tons of gold and 7,500 tons of silver are required respectively. When these products reach the end of their usable life, they become Waste Electrical and Electronic Equipment (WEEE). More than 50 million tons of WEEE is produced in the world annually. Out of it less than 15% of the gold in WEEE is recovered for reuse. Opportunity for recovering not only valuable metals like gold and silver but also many other metals like copper, tin, cobalt, palladium and other precious metals from the discarded consumer electronics is lacking. These discarded devices end up in landfills creating potential health and environmental hazards. On the other hand, around 54,000 tons of gold is only available below the ground reserve. This will lead to face high demand for gold in upcoming decades. Hence it is necessary to recover gold from e-wastes and save it for future supply.

KEYWORDS: Waste Electrical and Electronic Equipment (WEEE), Gold usage, Gold recovery methodology, Future demand and supply.

I. INTRODUCTION

Although, electronics have immensely helped in the nation's development in various sectors such as education, trade and commerce, it has also given mankind a reason to worry [1]. The world produces more than 50 million tons of Waste Electronic and Electrical Equipment (WEEE) per year. Only 20% of this is normally recycled. The waste produced annually is worth over $62.5 billion which is more than the GDP of most countries. In addition to health and pollution impacts, improper management of e-waste is resulting in a significant loss of scarce and valuable raw materials, such as gold, platinum, cobalt and rare earth elements. There is 100 times more gold in a ton of e-waste than in a ton of gold ore. Currently world's 7% of the gold may be present in e-wastes [1]. However, globally less than 15% of the gold in e-waste is recovered for reuse [2]. The best way to deal with e waste is recycling it. By recycling, the precious materials present in the e-waste can be recovered and can be used as a constituent material for new products. So that, the material that is to be mined from earth gets reduced. Reducing the mining also reduces pollution, process cost, energy and impact of mining on our environment [3].

II. CLASSIFICATION OF WEEE

EMPA (Eidgenossische Materialprufungs- und Forschungs Anstalt) Swiss federal laboratories have classified WEEE into two categories viz. Electrical waste and Electronic waste [4]. About 50% of WEEE consists of electrical appliances including household objects like washing machine, refrigerators, air-conditioner, vacuum cleaners, iron boxes etc. The remaining 50% of WEEE consists of electronic wastes which include personal computers, televisions, mobile phones, printers, radios, electronic medical instruments, drilling and sewing machines, etc. [5]. These goods are classified into three types namely white goods, brown goods and grey goods. The typically large electrical goods and heavy consumer equipment which are mostly painted with white enamel are called white goods. It includes refrigerator, stoves, washing machines, etc. The relatively light consumer equipment as well as the IT and telecommunication equipment such as television, computers, mobile-phones, radio-sets, printers, etc. are called brown goods. Whereas, branded goods sold outside the authorized territory by unauthorized dealers at a price lower than that of the manufacturing territory are called grey goods [6].

III. METALS IN WEEE

E-waste contains a wide range of metals. 50% of which constitutes of gold, iron and steel followed by 21% plastics, 13% nonferrous metals and 16% other constituents like rubber, concrete and ceramics [7]. Worldwide electronic manufacturers uses $21 billion worth of gold and silver (320 tons and 7,500 tons, respectively) [2].During the last four decades, considerable quantities of gold have been used by the electronic and electrical industries in view of its excellent electrical conductivity, low contact electrical resistance for inserting connections and outstanding corrosion resistance [8].

The following Table.1 represents the amount of various valuable metals present in different types of WEEE) [9].

As mentioned earlier 300 tons of gold is utilized in electronics each year which equals around 12% of annual mining production of gold. Its efficient recovery from electronics scrap represents a greater resource, which results in potential market supply. Electronic equipment constitutes of wide variety of materials (both valuable and hazardous). Hence it is essential to recycle e-wastes for environmental health as well as to meet future demand for the valuable metals [10].

IV. RECOVERY METHODOLOGY

Pyro-Metallurgy: In this method containing scraps are burned at high temperature by incineration and then smelting in a plasma arc or blast furnace.

Table.1 Metals present in various types of WEEE

Equipment	Lead	Nickel	Aluminum	Iron	Copper	Silver	Gold	Palladium
	Metals present in %				Metals present in ppm			
Printed wiring board	26	29	29	29	22	-	0.04	-
Printed circuit boards	2-3	2	7	12	16	280	110	-
PC scrap	1.5	1	5	7	20	1000	250	110
PC main board scrap	2.2	1.1	2.8	4.5	14.3	639	566	124
TV scrap	0.2	0.04	1.2	-	3.8	27.1	27.1	27.1
TV board scrap	1	0.3	10	28	10	280	17	10
Mobile phone scrap	0.3	0.1	1	5	13	`1340	350	210
Portable audio scrap	0.14	0.03	1	23	21	150	10	4
DVD player scrap	0.3	0.05	2	62	5	115	15	4
Calculator scrap	0.1	0.5	5	4	3	260	50	5

Sintering, melting, dressing, and reactions in a gas phase at high temperatures are conventional method to recover gold from ores [11]. As a traditional technique this method had been used for recovery of precious metals for many years from used materials, however it has encountered challenges from environmental considerations. Also state of art of smelting demand huge investments [12].

Hydro-Metallurgy: The important part of hydrometallurgical process contains acid or caustic leaching of gold containing materials. Followed by it, the solutions are taken to separation and purification procedures like solvent extraction, adsorption, precipitation of impurities, and ion exchange process to isolate and concentrate required metals. Then the solutions are subjected to cementation, electro-winning, crystallization or chemical reduction for recovery of gold [12]. There are different types of hydrometallurgy techniques for metal recovery process like cyanide leaching, thio urea leaching, halide leaching, thio sulphate leaching and aqua-regia etc. [9].

Bio-hydrometallurgy: Bio-hydrometallurgy is most capable technique for gold metallurgical process. The important processes of this method are bio-oxidation and bio-sorption. Bio-oxidation has been successful in recovery of gold from metallic sulfides and major bearing minerals of gold in spent electronic materials by bacterially assisted reactions [13]. Bio-sorption process is passive physio-chemical interaction between charged micro-organisms and ions in solution. For this process both alive and dead micro-organisms can be used. Comparing with other methods of recovery, bio-sorption has more advantages like low cost, easy operation, eco-friendly and minimal chemical or biological sludge discharge. Some of the micro-organisms used for bio-hydrometallurgy process are pseudomonas aeruginosa, stenotrophomonas maltoplia (bacteria), verticillium luteoalbum, trichothecium sp. (fungi), calothrix pulvinata, anabaena flos-aquae (algae) [12].

V. STATISTICS OF MINED GOLD

Since 1950 around two-third (190,040 tons) of gold has been mined. Gold is virtually indestructible. This means it transforms from one form to another form and always exists.

- Total above ground stocks: 190,040 tons.
- Jewelry: 90,718 tons, 47.7%
- Private investment: 40,035 tons, 21.1%
- Official sector: 32,575 tons, 17.1%
- Other: 26,711 tons, 14.1%
- Below ground reserves: 54,000 tons.

Accurately estimation of the amount of gold which is left within the ground is not an easy task. Mining companies will estimate how much gold is remaining after each mining projects they operate. They can be divided into two categories. They are reserves (gold that is economic to mine at the prevailing gold price) and resources (gold that will potentially be economic to mine, subject to further investigation or at a different price level) [14].

VI. CONCLUSION

Each year gold mining yields extra 2000-3000 tons of gold, resulting in increasing mining rates. But these are going decline in few years. In current digital era, the usage of electronic and electrical equipments is increasing day by day. There may be a greater demand for gold in the future for the manufacture of motherboards and other components in electronic devices. Over 12% of e-waste is only potentially recycled each year around the world and the remaining is dumped to landfills. Recycling of e-waste is essential not only for the recovery of precious metals but also for reducing the hazards to the environment. Hence the process of mining gold and other valuable metals in WEEE around the world and saving it to meet future demand and supply is the need of hour.

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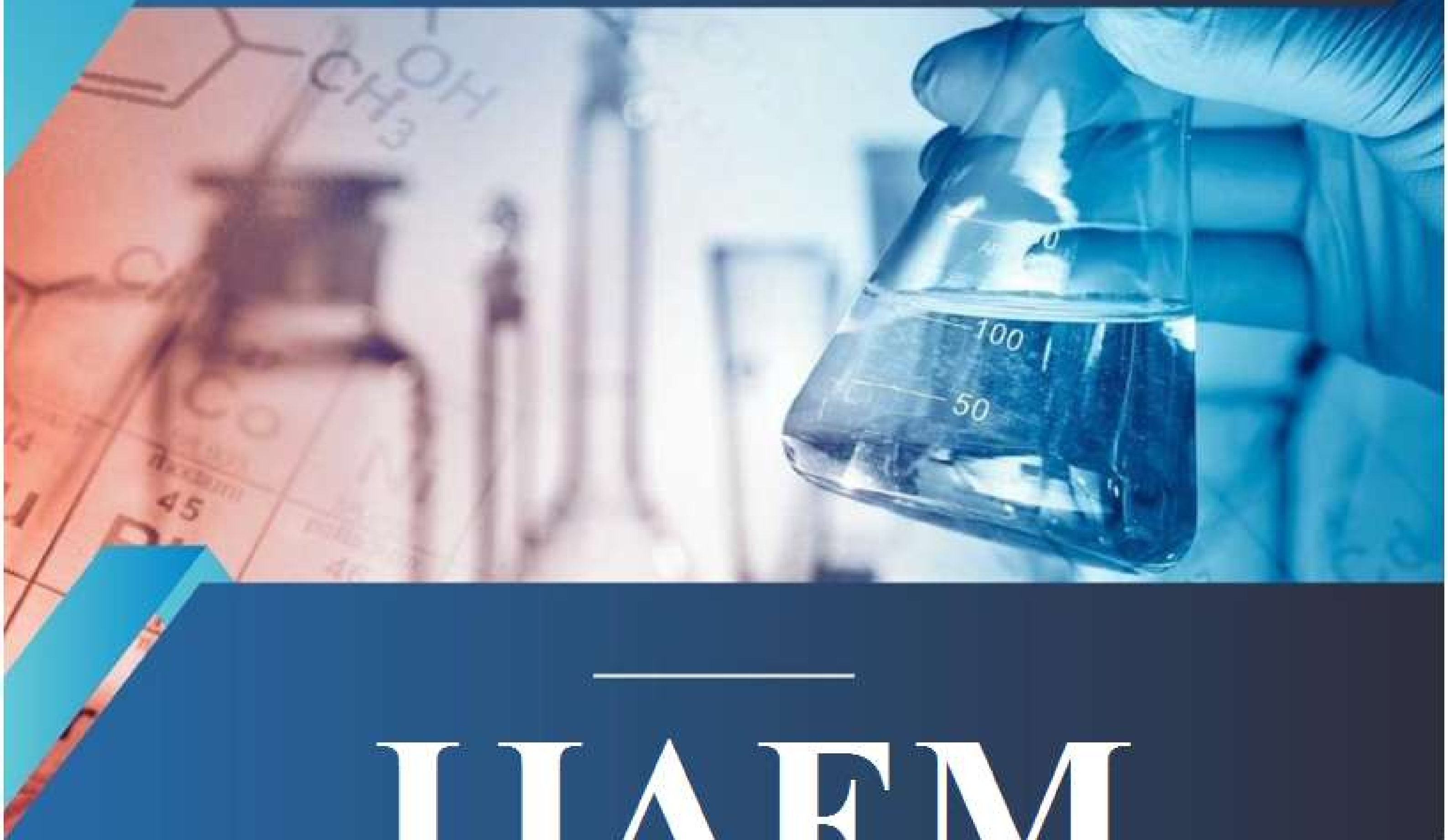

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