IMPROVED BY-PRODUCT RECOVERY, RECYCLING, AND REUSE

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Summary

By-products and wastes can be reused as resources and create economic efficiency. This article describes the status quo and the development of utilizing by-products and wastes, and discusses clean production and industrial ecology.

By-products, as the name suggests, emerge along with a product, and all kinds of wastes emerge from time to time in the process of exploiting raw materials and producing and using products. Although they are inevitable, by-products are not necessary for production and for human life. Their emergence not only creates a waste of resources, but also influences the environment in different degrees. If we could reduce wastes and tap technologies to use the waste and by-products a second time as new resources, we could to a certain degree reduce the consumption of natural resources by humankind. This is a crucial content in the strategy of reasonable utilization of natural resources. Although at our present economic and technological level we cannot eliminate wastes and by-products completely, we are making efforts in this direction so that we can fully use various kinds of resources in essential production activities, constantly enhance cyclic utilization of wastes and by-products, raise the efficiency of resources use, reduce the consumption of resources and energy to the greatest degree, produce as little waste

and by-products as possible, and help us live in harmony with nature.

1. The Environment and By-Products and Wastes

The metal reserves in the surface layer of the earth's shell are a major resource for metals. The limits of these metal resources confirm the importance of the efficient use of metals. Minerals, which are worth exploiting, are always found with other low-value or valueless vein minerals. Figure 1 show that the recovery rates of minerals are unsatisfactory at different stages. For example, in the exploitation stage (1) the rate is only 70%–95%, while in the processing stage (2) the rate is also very low—40%–95% for zinc, 40%–75% for tin, 60%–85% for iron, and 60%–75% for chromium. Therefore, 30% to 60% of resources are not exploited and become tailings. In addition, the rates of many minerals were originally not high and continue to show a downward tendency. Citing the U.S. standard in the 1980s as an example, the lowest mineral rate was:

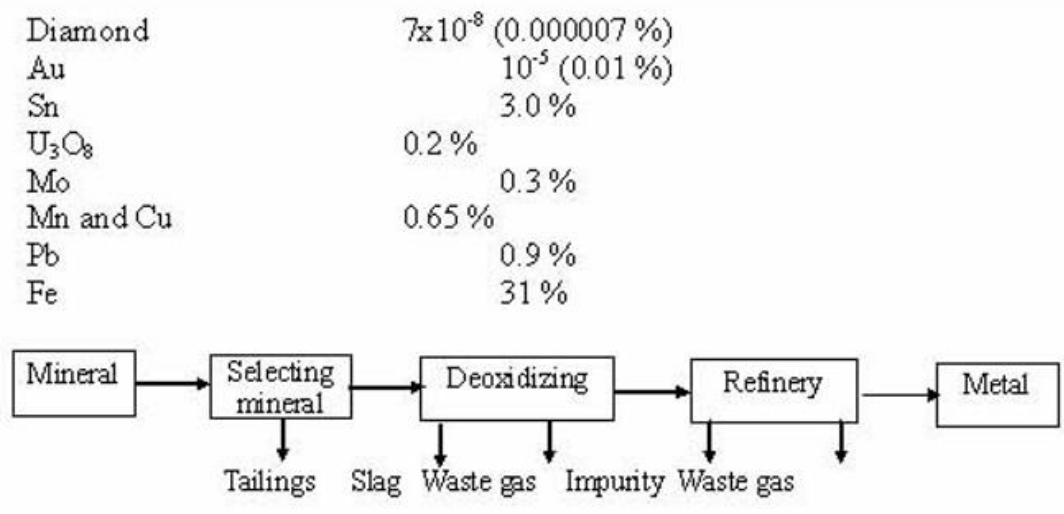

Figure 1. From mineral to metal: recovery rates of minerals

Therefore, the exploitation of mineral resources inevitably produces wastes and by-products. For instance, at present, the developed countries can reclaim 70 valuable elements from the selection and refinery process of non-ferrous metals. The comprehensive recovery rate has reached 80%.

Additionally, the lowest grades of ores are different in different areas and change with the time. For example, the average grade of copper in China was 1.8% in the 1950s, 0.76% in the 1980s, and could be exploited at the grade of 0.2%–0.3% by the end of the century. The average grade of tin was 1.68% in the 1950s, and was reduced to 0.2% in the 1980s, while the grade of tungsten has reduced from 3% to 0.25%. Advanced technology has also enabled the exploitation of ore of increasingly lower grades, but

excessive exploitation has accelerated exhaustion of the resources. Because of the low grades of ores, a large amount of materials needs to be worked on in the processing stage. For instance, in 1991, 100 tons of ore with an average grade of 0.91% had to be processed to produce 1 ton of copper. In 1994, about 200 tons of lower grade ore (average grade of 0.5%–0.6%, of which 80% was recoverable with current technology) needed to be processed, and all the rest was waste. Clearly, the grade of mineral resources will keep falling along with the massive consumption of humankind and exploitation will become increasingly difficult in spite of the development of science and technology, constant exploitation and application of technology, and the rising of labor productivity and the application rate of resources. For this reason, every stage from exploitation to refinery demands better methods to raise recovery rates, reduce costs, expand application of the by-products, and eliminate wastes. In recent years, the Bis-leaching method was developed to recover copper from low-grade ores or impurities.

Minerals	Average grade (%)	Ore (million tons)	Waste[a] (million tons)
Copper	0.91000	1000	990
Gold	0.00033	620	620
Iron	40.00000	906	540
Phosphate	9.30000	160	140
Potash	17.00000	160	130
Lead	2.50000	35	130
Aluminum/bauxite	23.00000	109	84
Nickel	2.50000	38	37
Tin	1.00000	21	21
Manganese	30.00000	22	16
Tungsten	0.25000	15	15
Chromium	30.00000	13	9
Total		3200	2700

[a] The figure for waste does not include the overburden. Because of rounding, the individual items do not exactly equal the total.

Source: Worldwatch Institute, based on production estimates in U.S. Bureau of Mines, *Mineral Commodity Summaries 1992* (Washington D.C., The Bureau, 1992), and grade estimates in Donald G. Rorich, Trends in material use, implications for sustainable development, unpublished paper (Division of Mineral Commodities, U.S. Bureau of Mines, April 1992).

Table 1. Average grade of some conventional ores and estimated output of minerals and waste

In the process of producing and applying the products, a large amount of solid wastes are inevitably generated. Solid wastes pollute the environment in many ways. Many countries pour wastes directly into rivers, lakes, and seas and even pour solid wastes

into the seas. After entering the water, the solid wastes not only directly affect the life of the plants and animals in the water, degrade the quality of the water, reduce the water area, but also, through the food chain, affect the lives of those associated with the water. With the atmosphere, the tailings, fly ash, and slag and dust particles in solid wastes enter the atmosphere on the wind, directly influence visibility and human health. And the poisonous and smelly gas from the burning of the wastes also directly affects the quality of the atmosphere. Wastes also influence the soil, damaging the living conditions of microbes and impairing the structure and quality of the soil. Poisonous and harmful wastes can also adversely affect the environment because of improper disposal, and this has become a common environmental problem internationally. The adverse effects of solid wastes on the environment in the late twentieth century has driven humankind to continue to develop technologies of treating solid wastes as well as technologies of turning them into resources.

To summarize, there are many by-products and wastes on the earth, and they cause excessive use of natural resources and bring many troubles to human lives. Some of them even affect in different ways the environment on which humankind depends for its survival. Therefore, humankind should pay more attention to these by-products and wastes, making efforts to turn them into resources while doing the utmost to reduce them.

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Biographical Sketch

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