

Proposal for the Promotion of Materials Recycling

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A human being has been using more and more materials for promotion of its life level year by year. The materials are originated from the Nature. We must think that a human being temporarily borrows them from the Nature. So we should return them in the same form as the origin into the Nature. However, it is impossible because it has been irreversibly changed into different phase. This attributes destruction of the Nature, i.e., pollution of the Nature. For environmental prevention of the Nature from pollution, we should try the entire recycling of materials by returning the used materials in the safe form even if it has a different phase in comparison with the original state. This article proposes the entire recycling of materials for keeping the EARTH

Key words : Materials recycling, energy and mineral resources, recycling promotion

Introduction

In ancient, there was no pollution problem. At the time pollutants and/or wastes from the living sites could be self-purified naturally. As population was increasing from the beginning of the 1900s, the earth circumstance has been changing due to discharge of much amounts of wastes. Self-purification has not been effective in the industrial complexes from the middle of the 20th century.

Industrial development contributes improving the living level of human being. However, it attribute generation of much amount of polluting materials by mass production, so the earth suffers from the pollutants which make environmental big troubles; i.e., greenhouse effect due to carbon dioxide, destruction of ozone layer due to CFC, water pollution due to hazardous materials in effluent, etc.

Up to the 20th century, the treatments of wastes like waste water, emission gases with detrimental ingredients and solid wastes had been considered as additional processes which made only cost. So many companies would be used to reduction of environmental investment, that attributes made bad effect on the ecological system as well as environments. However, everybody is beginning to consider "the earth is only one, so the earth should be kept to be clean without pollution". Also most of middle/small companies as well as big ones change their mind about the environment. They start to increase environmental investment for the clean production and reduction of wastes generation.

In the 21st century, production plant should be operated in the environment, while environment was taken account of being a part of the plant in the 20th century. So this article would like to discuss the proposal for resources recycling which is focused on the minimum or free discharge of the wastes on the earth.

Energy resources^{1,2)}

Primary energy sources of petroleum, natural gas, coal, hydraulic power and nuclear power reached 6,729 M toe in 1980 and 8,534 M toe in 1999. So it was increased by 26% during about 20 years shown in Table 1. The major energy resources are fossil fuels like petroleum, natural gas and coal, which are the sources of carbon dioxide generation. From the second half of the 20th century, energy consumption rapidly increased and then the carbon dioxide contributes the green house effect, which causes to increase average temperature of the earth and so dissolves the ice in the arctic. Meteorologists insist that it raises the sea level and may contribute abnormal weather. Therefore, they think that many disasters happen at many places on the earth. For prevention from those disasters, Tokyo protocol was agreed to control the emission of carbon dioxide by developed countries. However, undeveloped and developing countries don't agree the protocol, because they should permit to generate the gas for their economic and industrial development. This topic is to be a hot issue between developed and developing countries.

As shown in Table 2, the greatest amount of energy was consumed in the North America, which reached about 8.42 toe/capita. And Oceania and Europe had 3.7 toe/capita or higher, i.e., about 45% to the North America. South America and Asia, in which there are many developing countries, used about 0.68 to 0.72 toe, i.e., only about 8.3% to the North America. However, Africa, in which most of countries are categorized to be undeveloped, had energy consumption of 0.32 toe/capita, i.e., only 3.8% to the North America. Difference between continents occurs big. So developing and undeveloped countries want to promote their economic and industrial level in spite of emission of carbon dioxide.

Reserves and consumption of resources

Table 1. World's consumption of primary energy resources.

(unit: M toe)					
year	1980	1985	1990	1995	1999
Petroleum	3,024	2,803	3,135	3,235	3,462
Natural gas	1,286	1,491	1,771	1,912	2,064
Coal	1,815	2,100	2,245	2,207	2,130
Hydraulic power	432	174	189	216	227
Nuclear power	172	382	517	600	651
Total	6,729	6,950	7,857	8,170	8,534

Table 2. Primary energy consumption per capita upon continents in 1999

Continent	energy consumption		Population		TOE/capita (A/B)
	M TOE(A)	%	x1000(B)	%	
North America	2,557.3	30.0	303,694	5	8.42
Oceania	116.5	1.4	30,234	1	3.85
Europe	2,709.4	31.7	729,451	12	3.71
South America	271.2	4.3	515,573	9	0.72
Asia	2,818.5	29.5	3,680,719	61	0.68
Africa	261.2	3.1	810,159	13	0.32
Total	8,534.1	100.0	6,069,830	100	1.41

Mineral resources²⁾

Table 3 shows world's reserves and production of major minerals in 1999. This table says world's reserves of minerals were about 325 trillion tons and 1.5 trillion tons of metals and/or minerals were produced in 1999. If it is continued to produce mineral resources as much as that in 1999, then the mineral resources will be totally exhausted within about 220 years. How do they get the resources after 220 years? The natural resources is unrecoverable on the Earth. So we must save resources of energy and minerals.

Table 3. Mineral reserves and production in 1999.

Minerals for industry	reserves	production	remarks
steel industry*	144,445	1,024	
base metals*	27,870	39	
chemical industry	47,176	350	
electronic industry*	153	3	
refractory materials	105,919	70	
Total	325,563	1,485	

* on the base of metal, unit : million tons

others has million tons of ore

In order to get resources, we should excavate much more volume of ores, of which a considerable volume is discarded as wastes rock of gangues. In practice, Enrichment^{3,4)} reaches about several times to tens times as shown in Table 4. This means that a great amount of

gangues must generated as solid wastes on the surface as well as that large volume of excavated cave must be remained as empty space in the sub-surface of the Earth. Such action of human makes destruction of the earth and contributes disasters.

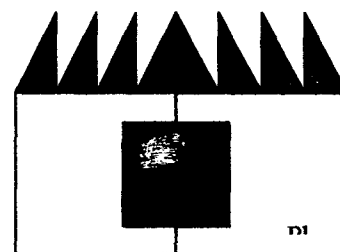
Talbe 4. Salable and minable grades of some minerals

mineral	salable grade,%	minable grade,%	enrichment
copper	> 29%Cu	>2%Cu	14.5
iron	> 60%Fe	> 20%Fe	3.0
lead	> 70%Pb	> 3%Pb	20.0
zinc	> 50%Zn	> 10%Zn	5.0
tin	> 40%Sn	> 1%Sn	40.0

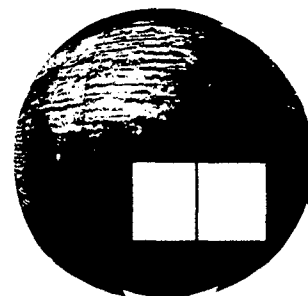
The earth should be kept clean, not destructive, by saving the resources. Their best way is 3R(Reduction, Reuse and Recycle) to save resources and to reduce generation of wastes.

Concept of clean production

At beginning of 1990, production activity was starting to be changed to the campaign of reduction of raw materials as well as lower generation of wastes. The eco-efficiency was introduced as a concept of business at the beginning of 1990s⁵⁾. So the plants is in the environment at present while environment is considered a part of plant beforehand. The concept can be explained by a picture shown in Fig. 1. Now the recycling and safe treatment of wastes are essential for saving resources and protection of environment.



Environment in plant



Plant in environment

Fig. 1. Environment in the plant(old) and plants in environment(new).

Proposal for recycling

Wastes are generated in three types of gas, liquid and solid from industrial and living areas. If possible, free discharge of wastes is ideal. However, they shall be inevitably originated by the industrial and living activities.

Fig. 2 shows life cycle of resources from the Nature. We get all the primary resources from the Earth. So minimal amounts of resources should be excavated for extension of

resources and environmental protection. For fulfillment of them, 3R campaign is greatly important. As you know well, it means reduction, reuse and recycling. At first, reduction of wastes results in the resources saving. Secondly reuse controls the overproduction and thirdly recycling regenerates raw materials from the wastes. Therefore, 3R campaign strongly contributes resources savings and environmental protection.

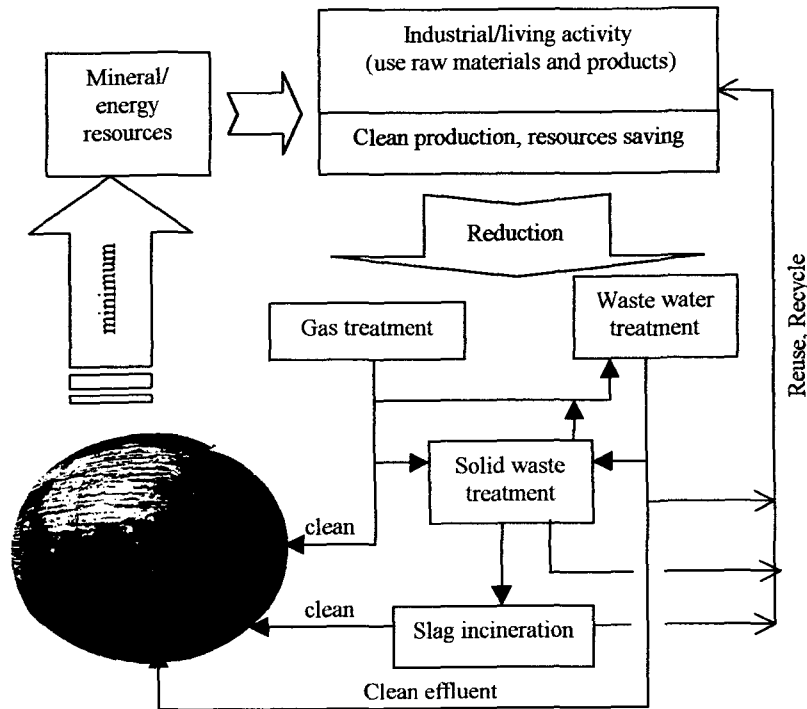


Fig. 2. Life of resources.

Up to 21st century, most of discharged materials have been treated by simple environmental concept to incinerate for volumetric reduction and to landfill for easy discarding. Also the environmental treating cost meant only the expenditure, which was considered as a loss. If we, however, put wastes into the earth, the environment could be polluted with hazardous materials. And then we must pay much more efforts to recover the environment, that is a great social cost. So Industrial and living activities should be conducted without generation of pollutants. Such a campaign was originated from developed countries. So they insisted "cleaner production" and 3R campaign. If the environment may be contaminated with hazardous materials, we can't get water to drink and food to eat. Those things become terrible for life and then great disasters happen.

Therefore, wastes must be essentially reduced, reused and recycled to save resources and protect the

environment. For the purpose, incessant researches should be conducted for newly effective technology with appropriate investments.

For the entirely safe processes of wastes, a combination process must be established for recycling of secondary materials and for treatments of gases, wastes water and solid wastes. As shown in Fig. 2, all the generates from industrial and living places may be treated with each process at first. Gas cleaning produces generally liquid and/or solid wastes, which should be processed in the other lines of treatments of wastewater or solid wastes processes. Likewise, processes of wastewater and solid wastes may produce another wastes. So treatments and/or recycling can handle all kinds of wastes by combination processes.

Gas treatment

Most of industrial plants can emit some kinds of hazardous gases, which are SO_x, NO_x, CO, halide compounds, volatile organic compounds(VOC), etc., normally contained solid suspensoids. Various processes can be applied to collect solid particles and hazardous materials and/or to fix the toxicity of them. An easy method is scrubbing, which generates inevitably wastewater with solid particles. That must be processed to recover valuable materials or to fix hazardousness. Gas treatment processes are listed as follows:

- o dust collection by cyclone, bag filter, electrostatic precipitator(EP), etc.
- o scrubber for collection of hazardous materials like SO_x, NO_x, CO, halides, VOC, solid suspensoid, etc.
- o oxidation/reduction processes such as selective catalytic oxidation/reduction, plasma process for decomposition of VOC

Wastewater treatments

Water is an essential material for living life. All the animals and plants don't hold their life without water. Of course, industrial activity should need water for producing goods. The process water is changed into wastewater through industrial and living activities. If wastewater is discharged into the fresh water stream without cleaning, all the living things meet with great disaster enough to lose their life. So it is very important to clean the wastewater in order to keep the life as well as to protect the environment. In general, wastewater contains heavy metals and organic materials as hazardous and toxic ones with many kinds of salts which are not yet restricted strictly. However, heavy metals become to be valuable when they are recovered as concentrated forms. So we should process wastewater for saving resources as well as protecting environment. Of course, heavy metals can be recovered to recycle as useful materials as far as possible. For getting it, many processes can be applied like followings.

- o separation of solid particles and suspensoids
 - thickening and settling
 - filtration
 - microfiltration(MF)
 - ultrafiltration(UF)
 - nanofiltration(NF)
 - reverse osmosis(RO)
- o treatments of organic compounds in wastewater
 - bio-deterioration for removal BOD
 - chemical treatments to reduce BOD/COD and metals
 - electrochemical processes for removal of COD/BOD and metals
 - adsorption techniques to remove organic compounds and heavy metals
 - plasma and ion beam processes to decompose organic compounds
- o recovery or fixation of inorganic and/or metallic materials
 - electrolytic process

- electrolytic dialysis
- ion exchange process
- adsorption process
- chemical process
- solvent extraction
- selective membrane electro-dialysis

In most cases of wastewater treatment, sludge is normally produced. The sludge contains higher content of water than 75% and sometimes over 90% moisture. If hazardous ingredients like heavy metal or detrimental organic compounds are contained in it, then it is classified as hazardous wastes and particularly mandated to handle as well as to be treated. Here, the most important thing becomes to reduce water content enough to handle easily for recycling and treatment. Some engineers have been tried the reduction methods of water content in the sludge by using surfactants and specially designed filters.

Solid waste treatments

Additionally generated solid materials from industrial and living activities generally reach large volume and contain many kinds of components, of which some has a considerable amount of valuable materials and/or the others contain toxic or hazardous materials. There are many companies that recover valuable materials from the wastes for recycling. However, most of them are definitely small business in Korea. So they don't have a sophisticated technology for recycling and/or waste treatments. Also they are subjected to companies which generate solid wastes. Sometimes, companies to generate wastes may change the company to treat their wastes. Then small business to handle solid wastes don't get raw materials, so called, solid wastes for recycling and/or waste treatment. In this case, the company can't help closing because of being lack of raw materials. So it is better to have a strong relationship between companies of generating wastes and those of treating them.

Solid wastes are treated for recycling and waste treatments by followings.

- reuse through repair or not
- recovery of valuable materials by physical and/or chemical separation
- landfill by fixation or not
- incineration with/without recovery of energy
- composting

If additionally generated materials are discarded or landfilled on the earth without recovery of valuable materials and fixation of hazardous materials, considerable resources should be thrown away and environmental pollution should be given rise. That causes excavating much more resources following damage of the Nature. The entire recycling can be proposed to recover valuable materials and to safely fix the detriments by combination of processes for emitted gases, discharged wastewater and generated solid wastes. So it is performed that clean gases can be emitted into the air, clean water discharged into fresh water system and environmentally

friendly solid materials returned to the earth by slag incineration of residual materials at last stage.

Institutional supporting system

Recycling companies tightly rely upon companies which generate wastes because they are definitely raw materials for them. The additionally generated materials with valuable materials can be traded by free competition. However, worthless wastes should be paid for safe treatment. If these materials are not properly processed to landfill, environment must be polluted to make bad effects on living life as well as human being. Who takes charge of treatment cost? Of course, those are beneficiaries who get interests with the material. For example, those are to be producer and/or consumer. Now some countries are carrying out "waste charge system". In Korea, both "deposit refund system" and "waste charge system" have been enforced since 1980s. These systems are applied to items which are generated at unspecified places. Recyclable wastes are categorized into "deposit refund system" and non-recyclable ones without economic feasibility into "waste charge system". The former items are can, paper, bottle, electric appliances, etc., the latter plastics, tire, etc. In practice, most of deposit and charge are supported to collection of the wastes and little bit used for the recycling. Companies to generate wastes take charge of treatment cost whether they treat them by themselves or outsourcing. Anyway, a certain institutional supporting system is absolutely needed for promotion of recycling and safe treatments of wastes.

Another thing is to strongly tie between companies to generate and handle wastes. As talked about it beforehand, companies for recycling and/or fixation of wastes inevitably rely on the companies to generate them. So recycling and/or fixation companies should have a strong and cooperative relationships with companies to generate wastes, because wastes absolutely become raw materials for recycling and/or fixation companies. The

reason is to run steadily recycling without collapse by over-competition between small recycling companies.

Summary

For effective environmental protection and resources savings, 3R campaign is thoroughly carried out. Companies to recycle wastes have better relationships with ones to generate them for sustainable recycling of wastes. Also over-competition between recycling companies may be avoided as far as possible, because they can raise the treatment cost for getting wastes as raw materials. Institutional supporting systems like "deposit refund system" and "wastes charge system" are needed for better recycling and treatment of wastes.

And strict regulation of discharge should be employed for discharge level into fresh water by limiting the conductivity. And strict regulation on the landfill should be enacted for sanitary landfill. Also solid wastes are recommended to discharge in the form of safe slags, artificial rocks, which can be produced by controlling composition for environmentally friendly materials. Then they can be recycled as good materials for construction.

So combination processes can make nearly perfect wastes recycling and so it is expected to save resources and to protect the Earth.

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