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Rethinking Social Costs of Wastes Associated with the Mining Operations in Ghana from an Environmental Perspective.

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Abstract

According to the Ghana Environmental Action Plan (1994), Ghana is endowed with abundant natural resources, which have played a very important role in the agricultural and industrial efforts of the country. In the process of exploiting these resources to meet the legitimate socio-economic needs and aspirations of her people, however, adequate care has often not been taken to guard against the destruction of the environment. In the light of these problems caused by improper waste management there is much cause for concern, particularly, in the mining concentrated areas in Ghana. The main objective of this paper, therefore, is to examine and explain the impact of poor management of wastes from mining on the environment. In view of this, it has been suggested that the government of Ghana and all the agencies concerned with environmental safety be actively involved in enforcing and ensuring that the mining companies in the country manage their wastes in an environmentally friendly manner. In addition, if the mining operators fail to effectively manage their wastes in an environmentally friendly manner and therefore affect the environment, they must also be made to pay part of the waste management cost. Perhaps, this can serve as a yardstick and a basis for effective monitoring of the activities of the mining firms to ensure sufficient air, soil and water quality in the country.

Key words: assimilative capacity, replenishable resource, pollution, prevention costs, intergenerational externality.

1. Introduction

The Ghana Environmental Action Plan (1994) explains that mining is one of the main sectors that contribute significantly to the nation's development but its activities are usually associated with a number of problems such as land devastation, soil degradation, and water and air quality changes. These resources served as the springboard for the country's industrial development after the attainment of independence and they remain the fundamental endowment from which the nation's people derive their livelihood. Over the years, the quantity and diversity of mining wastes have increased. However, there are hardly any waste recycling or proper management practices in the country. Mine waste has become a major problem and in a growing list of communities around the world, it has reached crisis proportions.

2. The Need for Proper Waste Management

(Saigo and Cunningham, 1995) stressed the fact that the definition of wastes as being hazardous or not varies from one country to another. One of the most widely used definitions is contained in the United States Resources Conservation and Recovery Act, 1976. The Act considers wastes as toxic and/or hazardous if they "cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacity reversible, illness, or pose a substantial present or potential hazard to human health or the environment when improperly created, stored, transported, disposed of, or otherwise managed". This definition gives us a detailed insight about wastes and their associated problems, namely: (a) It defines wastes as toxic or hazardous (b) It tells us the extent of toxicity or hazardously of wastes (c) It tells us the causes and the processes through which wastes could cause harm; and (d) It also tells us those that are affected. That is (i) Humans- health, illness, accidents, death, fatality, and mortality (ii) Non humans-plants, animals, water bodies and aquifers, soils and landscapes, and aesthetics (iii) Other activities affected include agriculture, fishing, hunting, and recreational activities.

It should also be noted from the foregoing that wastes may either be hazardous or toxic if they cause or significantly contribute to: (a) An increase in mortality; (b) An increase in reversible or irreversible illness (human health); (c) An increase in environmental destruction which also affects the quality of human life and (d) Actual or potential threat to other living organisms and the environment in general. It is also inferred from the above definition that wastes, whether hazardous or toxic, can cause or contribute to the above problems in society if they are improperly created, stored, transported, disposed or managed. It is in the light of these problems caused by improper waste management that there is much cause for concern, particularly, in the mining concentrated areas in Ghana. Over the years, the quantity and diversity of mining wastes have increased. However, there are hardly any waste recycling or proper management practices in the country. To minimize the negative effects of poor waste management, there is the need to identify a framework to serve as a basis against which mining companies should behave towards the environment.

3. Literature review

Solid wastes disposal and management is vital to the development of a country and it is, therefore, not surprising that it has attracted the attention of many writers. Statistics currently available show that good sanitary practices have the potential benefits of enhancing the health of the people. A readily available supply of safe water and the sanitary disposal of wastes, for instance, are known to be among the essential ingredients of a healthy productive life. Chiras, 1994) stated that a World Health Organization (WHO) expert committee's technical report on environmental sanitation in 1954, rated the proper management of mining, medical wastes and other forms of wastes as among the basis for ensuring a safe environment for any community. The Environmental Protection Agency in Ghana (1994) maintained that excess of different metals could prove toxic to most plants and animals. To support this fact Table 1 provides how the concentrations of certain elements (heavy metals) can be toxic to living organisms. The elements in Table 1 are usually common in most mine wastes. Each of them has a range and degree of toxicity to human and plants. The chemical constituents in mine wastes create various health problems for humans and also impact on aquatic organisms. In the case of chemical constituents, studies have shown that the health aspects arise from the different impact, which the constituents have on human body. These are:

- Constituents, which exert acute and/or toxicity upon consumption. The human body is able to tolerate a certain level only beyond which it cannot. Examples are metals, nitrates and cyanides. Higher concentration of cyanide than the (WHO, 1984) drinking water guideline value has been found in the waters of Jimi River in the Offin Basin (WRRI, 1988). The same situation was found by (Osafo, 1988) in the Ankobra basin. The sources were effluents from gold mining operations.
- Constituents, which are carcinogenic or mutagenic and cannot be tolerated at any level. Examples are some pesticides and arsenic. In the gold mining areas, waters receiving mining effluents contain certain levels of arsenic beyond the (WHO, 1984) guideline value for safe drinking water.
- Constituents which are necessary for human health. Examples are iron, fluoride and iodine. Deficiency of these can be detrimental to health, but higher concentrations than optimum can also be detrimental. Some of the consequences of deficiency for these effluents are tooth decay or rejection of suppliers. (Amusu, 1974) has shown that about 30% of the groundwater suppliers have high iron concentration beyond the (WHO, 1984) guideline values, and these have resulted in rejection with consequent loss of investments.

It is therefore, evident that most wastes from mining and other manufacturing industries contain hazardous and toxic chemicals that require much attention and care. It is noteworthy that it is still not possible to quote definite toxicity concentrations of individual metals because of the many factors involved. This is because there are usually several metals involved and the interactions between them may multiply the potential problems (synergistic effects). For example, combinations of metals in solution such as nickel and zinc, copper and zinc, and copper and cadmium are more toxic than their individual toxicity would suggest. Alternatively, the presence of phosphates or calcium can reduce the toxicity of lead, zinc and copper (antagonistic effects).

(Agyemang, 2012) reported that an international waste management expert, Dr. Paluarajan Devananda has advised the Government of Ghana to invest more in waste management to reduce their impact on the environment and the health of the population. He also called on the government to invest in new technologies that would help segregate e-waste and plastics from other waste materials to ensure their proper treatment and recycling. Speaking at the national conference on new and innovative approaches to waste management organized by All Nations University in Koforidua, Dr. Devananda stated that the inability of most governments to fund research into e-waste and plastic materials has led to the dumping and burning of such waste on refuse dumps. (Bentil, 2012) reported that Newmont Gold Ghana Limited presented a cheque for GH¢3.1 million for the Asutifi District Assembly as part of the GH¢7 million fine the Company was asked to pay following its cyanide spillage into the River Yaakye and its tributaries at Kwabuokrom, near Kenyasi in the Brong Ahafo Region. In addition to this, the cyanide spillage in Asuman and Huni rivers at Abekoase and Huniso near Tarkwa by Goldfields Ghana Limited (GGL) in October 2001 is also an instance of concern. (Kojo Sam, 2001) reported that four months after the incident, the company agreed to pay a compensation of one billion cedis to the communities affected, but the communities rejected the amount as being insignificant. These and many other issues about mismanagement of wastes from mining operations in Ghana should be a major cause for concern for all stakeholders, hence this paper is a step in the right direction.

4. Theoretical Model: Material Balance Model of Waste Management

(Pearce & Turner, 1990) pointed out that, based on Material Balance Model the physical environment of mankind has three life sustaining functions:

1. As a source of input to productive activities to sustain human life and welfare (quantitative input)
2. As a source of input into assimilation of less useful materials associated with productive resources (physical inputs)
3. As amenities of nature enjoyed directly by humans including air quality, water quality, etc (qualitative input).

Figure 1 clearly illustrates these three life sustaining functions of the environment. It is clear from Figure 1 that the solid wastes and other pollutants that we spew forth are chemically broken down and reabsorbed in a relatively harmless form into the environment in a short period of time. Society has assumed nature as a "sink" into which we pour wastes, and nature readily treats and reabsorbs these wastes. The extractive activity comprises the production of goods and services. It is clear from Figure 1 that the solid wastes and other pollutants that we spew forth are chemically broken down and reabsorbed in a relatively harmless form into the environment in a short period of time. Figure 1 clearly shows the three main activities where wastes can be generated: Extraction (E), Processing, Manufacturing and Distribution (P) and the final products for human consumption (C). These three functions are closely interrelated: productive activities yield both good and bad "things". Good things are used by humans for comfort and welfare. Bad things are returned into nature as waste or residue. These three main activities consist of the exploration of minerals and other natural resources, the extraction of these resources and harvesting them to ensure utility maximization and economic growth. The processing and manufacturing stage adds value to the resources that are extracted from the extractive industry to facilitate their distribution and consumption. The next activity is consumption, that is, the using up of the goods and services that are manufactured and distributed by the processing stage to satisfy human wants. It is evident from Figure 1 that with each of the economic activities to ensure survival, welfare and economic growth, waste is usually created or generated either in the form of a by-product or residue. The waste generated may be solid, liquid or gas, and almost all the wastes produced are toxic and hazardous to human health and the environment.

5. The Assimilative Capacity of The Environment

(Poole & Henderson, 1991) pointed out that the environment has a capability to take wastes and to convert them back into harmless or ecologically useful products. This is the environment's assimilative capacity (A) and it is the second major economic function of natural environments. So long as we dispose of wastes (W) in quantities (and qualities) that are commensurate with the environment's assimilative capacity, then we have, $W = A$. The circular economic system will function just like a natural system; although it will still draw down the stocks of exhaustible resources. The system will therefore have a finite life determined by the availability of the exhaustible natural resources and other considerations. If we dispose of wastes in such a way that we damage the capability of the natural environment to absorb waste, we may have: $W > A$, In such a situation, the economic function of the environment as a waste sink will be impaired. The assimilative capacity of the environment is thus a resource, which is finite. So long as we keep within its bounds, the environment will assimilate wastes and essentially return the waste to the economic system. If we stop all polluting activity today, therefore, within a short time, the sink and drain would clear and a pristine environment would re-emerge.

To foster economic growth and development, however, industrialization unfortunately, has accelerated and worldwide population levels have increased multifold since the World War II, and therefore, this simple story is no longer adequate. Nature's sink gets clogged, reducing its ability to absorb and break down pollutants. According to (Poole & Henderson, 1991), when nature's sink gets clogged, it cannot handle the flow of pollutants; rather than the environment absorbing the pollutants, the pollutants change the environment. These pollutants may change the composition of gas in the atmosphere, thereby altering the earth's temperature and climate. Major lakes and oceans may be so radically altered as to destroy all fish and most plant life, requiring decades to regenerate. Toxic wastes with half-lives of several generations may lie in wait in deteriorating containers to unleash their destruction on future generations. From the point of view of economists, when the sink gets clogged we have an intergenerational externality. The environment functions as a drain for our wastes and is a replenishable resource. But over-utilization today reduces its ability to absorb future wastes. With this in view, we can see that the pollutants of the next generation are more harmful to them because the sink is already clogged. From the view of (Poole & Henderson, 1991), these pollutants linger longer and do more damage to the future generations. Polluting more today, therefore, reduces nature's ability to function as a sink that is to regenerate itself toward a pristine condition and increases the damage from the pollutants for the next generation.

There are usually many dangers that arise from the mistreatment of natural environments because we do not recognize the positive prices for these economic functions. This is the essence of the Materials Balance Model analysis of waste generation and management.

6. Used Up Natural Resources and Environmental Costs

Depending upon the nature of the natural resources, the process of productive activity to enhance human welfare tends either to exhaust or deplete the resource. The first environmental problem that society encounters is **exhaustion or depletion.** In the process of creating "goods" to enhance human welfare, "bads" are also created. These 'bads' are called wastes or residuals. The wastes that are generated are usually thrown back into the environment. Depending on the nature of the wastes, nature may absorb them completely and turn them into useful products or may just contain them in their original form (biodegradable or non biodegradable). According to (Poole & Henderson, 1991), the ability of natural environment to absorb wastes one way or the other is its assimilative function. Waste generation occurs in three phases, that is, at the primary stage of extraction, secondary stage of processing and final stage of consumption. Each stage of human activity creates wastes, which must be disposed of in some way. The second problem society faces is **waste disposal** and **cost of waste management.** The cost to society is usually called **pollution prevention costs** or **abatement costs**. For example, a firm may treat its waste before releasing it into the environment, thus rendering it harmless to the environment. (Chiras, 1994) explained that if society is unable to accept the proper disposal costs and the waste is dumped into the environment to some critical level, the environment may not be able to assimilate the waste any further. In such a situation, **Environmental Degradation** or **pollution** occurs, and the quality of environmental amenities (i.e. air, water, etc) degenerates. Pollution costs involve damage avoidance costs (defensive or remedial expenditures) and welfare damage of pollution or externality costs (here, society accepts the consequences of pollution in terms of health, visibility, noise, etc).

If pollution is not prevented in part or avoided, then society must accept welfare losses or damages. For example, in a mining area society may accommodate unfilled excavations, removal of topsoil without rehabilitation, unsealed mine shafts, etc. The physical degraphlets may pose considerable hazards to individuals in the locality. Such damages can be measured in money terms though they are real phenomena. Anybody who visits a mining area can be affected by such physical damages to the environment. The most tangible pollution damage takes the form of observable deterioration of both physical assets and of living things, including human beings. However, the full welfare costs of pollution damage are difficult to estimate exactly. From the above discussion, a generalized cost equation can be formulated for Waste Disposal Costs (WDC), as:

Waste Disposal Cost = Pollution Prevention Costs or Pollution Avoidance Cost

(PPC) + Pollution Damage Cost (PDC) That is,

WDC = PPC + PDC

In general, pollution prevention costs (PPC) involve direct outlays by either the private sector (e.g. the miner) or the government to purchase resources to inhibit pollution. Since this tends to increase operation cost or initial investment cost, or both, private operators may not have any incentive to incur these costs. According to (Kneese & Schultze, 1975) such costs eat into private profits. Firms would find it expedient to dispose of raw waste into the environment for natural treatment. This is cost free because the environment's assimilative capacity has no market price. It is a free good. Pollution damage costs (PDC), on the other hand, are expenditures that are usually incurred to clean the environment after it has been polluted. Sometimes too, the waste matter is not treated but dumped raw into the environment. In the view of (Kneese & Schultze, 1975), the environment has been exposed to harmful materials and the effects must be mitigated by determining remedial expenditures e.g. clean up programmes or other expenditures to avoid contact or exposure. These constitute the pollution damage costs (PDC).

7. Discussions and Policy Implications

The Material Balance Model of waste generation dictates that economic activity inevitably creates waste in the form of materials and energy flows. Too much waste entering the environment rather than being recycled or reused (i.e. W>A) will over-stress the assimilative capacity of the environment to handle such wastes safely. The result will be a range of pollution and resource degradation impacts and consequent economic damage costs. Preliminary studies conducted by the Environmental Protection Council (1988); (Biney, 1982); (Acquah, 1988); and (Danso, 1988); have shown that the mining companies in the country generate varied forms of wastes and the rate at which the wastes are produced is far greater than the collection, recycling, reuse and disposal rates. Most wastes spend a lot of time on the ground before they are collected. Others spend months or years before they are collected or reclaimed. Apart from wastewater, no other form of wastes is recycled, even though many of them have some important uses. All these over-stress the assimilative capacity of the environment to haul wastes safely.

The principles of the Material Balance Model can be used to develop an overall strategy for the disposal and management of many forms of wastes and to control almost any type of pollution. The laws of conservation of matter give a limit to our pollution levels and they also caution us to realize that the most dangerous pollution threats to human health and the quality of our lives are slow and unseen. Among other things, we should, as early as practicable, manage the wastes emanating from our economic activities and consumption very well. Even though the economists may be more concerned about economic growth and human welfare, the quality of life depends on human security, a sound environment to live in, safety, comfort and other factors relating to health, pleasure and happiness. Even though we are faced with the problem of trade offs, our problem should be to developing strategies to control pollution of all forms. Although, there are numerous and significant gaps in the application of the Material Balance Model and our scientific and technological knowledge of pollution, we can institute short range control over many, if not all, of the pollutants currently considered dangerous. The major problems, however, are primarily political and economic ones of balancing the costs and benefits of pollution control versus other societal goals, such as eliminating poverty, providing adequate housing, jobs, education and defense, and deciding what is a cost and a benefit and to whom. Nevertheless, technology is essential in helping us to reduce pollution levels below the danger point, but in the long run pollution control must include population control and control of the amount and patterns of production and consumption. This is the essence of the Material Balance Model. In addition, wise use of existing technology can buy us some time to develop and institute new pollution control technology and new energy sources, to phase in an earthmanship economic and production system, and to achieve pollution stabilization in the years to come if we begin from now.

8. Conclusion

Actually, untreated wastes that are usually dumped into the environment for natural treatments do have real pollution costs. If a firm fails to incur the pollution avoidance costs, then it imposes on society pollution damage costs (social costs). Most private firms, left to themselves, would avoid both pollution prevention costs and pollution avoidance costs so that society bears all the social costs. Herein lies the role of a public contribution, institutions of state and governments to ensure that a greater part of the Waste Disposal Cost is borne by the private sector that generates wastes. It is the writer's view that if the suggestions below are adhered to, we can expect a bright future for Ghana's development–a pristine environment and good health for the people of Ghana. The success of the mining industry in managing and controlling their wastes efficiently depends on the concerted efforts of the government, mining companies, and environmental agencies in solving the aforementioned problems.

9. Recommendations

In view of the above, the author wishes to put forward the following recommendations:

9.1 Posting of Reclamation Bonds by Mining Industries

In June 1999, the EPA enacted Environmental Assessment Regulations (LI 1652), which required all mining companies to post reclamation bonds. The object of the bond was to provide financial security which ensures that irrespective of what happens to a mining company in the course of its operations, the reclamation or rehabilitation of its disturbed mine sites would be carried out. Since the enactment of the regulation, the Agency has conducted fieldwork, consultations with stakeholder and desktop research on reclamation plans and bonds. Even though a greater number of mining companies in Ghana, including Anglogold Ashanti and Newmont Gold Company are known to have successfully posted a reclamation bond by the close of 2011 (Environmental Protection Agency, 2012), there is a problem with its implementation and enforcement because many other mining companies have still not posted the bond. It is therefore my recommendation that, as a matter of policy, the laws and rules governing the posting of reclamation bonds be enforced and seriously implemented in Ghana after carefully working out the details.

9.2 Enforcement of Standards and Rules

In view of the low level of compliance by many of the mining companies in Ghana, it is also suggested that the EPA, and other agencies responsible for environmental safety should be given the necessary logistics and support to enforce standards and regulations that it sets. In addition to this, the government should, as a matter of extreme importance, work on mechanisms to ensure speedy procedures and set up courts to deal with mining companies that offend environmental rules.

9.3 Implementation of Environmental Action Plans

In view of the fact that most of the untreated wastes from mining operations spend months or years before they are collected or reclaimed, there was a low level of implementation of Environmental Action Plans at most of the disposal sites. In the light of this, it is also my recommendation that, in addition to ensure compliance with environmental laws, the Government, District Assemblies, the company and all other agencies responsible for the environment should be actively involved to see to it that the mining companies in the country strive to continually improve environmental performance at the mine sites taking into consideration the above observations.

9.4. Environmental Police and Courts

Another suggestion put forward is the creation of National Environmental Police Unit to handle environmental criminal cases. It is again, my recommendation that the Ghana Police Service, in consultation with the Attorney Generals Department would see to the immediate establishment of a National Environmental Police Unit and courts in the country to enforce existing laws and regulations pertaining to environmental quality in the country.

References

Abrokwa-Ampadu, J., (1987), "Proceedings (Vol. 1 & 2) from National Conference on Resource Conservation for Ghana's Sustainable Development", Organised by the EPC and Forestry Commission, Accra, 28th –30th April

Acquah, P.C., (1988),. *The Flotation of a Carbonaceous Sulphide gold ore form Ghana, A design study*, International Confer on The Geology of Ghana Accra. Floent Publishers, Accra.

Agyeman, K. A., (2012). "Daily Graphic" March 5.Amuzu, A. T,. (1974). "A study of Drinking Water Quality of Boreholes in the Rural Areas of Ghana, Water Resources Research Institute, Accra.

Baumol, W. J., & Blinder, A. S., (1991). Microeconomics, Principles and Policy. 5th. Ed. Harcourt, Brace, Jovanovich, Dallas, TX.

Bentil, K., 2012. "Daily Graphic"

Chiras, D.D., (1994). Environmental Science: Action for a sustainable future. 4th. Ed. Benjamin Cumming's Publishing co. Inc, California.

Danso, J. K., (1988). "Industrial Pollution In Ghana" Ghana Science Association Seminar On Ghana's Preparedness For National Disasters, UST, Kumasi,

Enger, E. D. & Smith, B. F., (1992),. "Environmental Science: A Study of Interrelationship" Toronto, 4th Ed W. M. C Brown Publishers

"Ghana Environmental Action Plan –Vol. 2"., (1994). "Technical Background Papers by Six Working Group", EPC,

"Ghana Environmental Protection Agency".,(1997) Annual Report

"Ghana's Mining and Environmental Guidelines" (1994). EPC,

Kneese, Allen V., & Schultze, C.L., (1975). Pollution, Prices, and Public Policy; the Brookings Institution, Washington, DC.

McConnell, Campbell R. & Brue, SL., (1993). Economics. 12th. Ed. McGraw-Hill, New York.

Osafo, R.,(1988). "A Report on the Preliminary Survey of Water Quality and Pollution in the Ankobra River.

Pearce, D. W, Turner, & R. K., (1990),. Economics of Natural Resources and the Environment. New York: Harvester Wheatsheaf.

Pigou, A. C., (1920). The Economics of Welfare in Dixon et al 1994 "Economic Analysis of Environmental Impact" London: Earthscan Publication Limited

Poole W, and Henderson, J. W., (1991)., Principles Of Economics, Toronto: DC Heath Publishers,

Saigo, B. W. and Cunningham, W. P., (1995). Environmental Science: A Global Concern 3rd Ed. Toronto: W M. C Brown Publisher.

Sam, K., (2001) "Daily Graphic, June 6"

Songsore., (1994,) "Mining and Environment: Towards a Win- Win Strategy. 'A study of the Tarkwa-Abosso-Nsuta Mining Complex in Ghana", A study prepared for the Ministry of Environment, Science and Technology (MEST-EPC) and the World Bank in support of the formulation of a Growth Strategy for the Western Region.

The Environet., (2001). EPA in-house Bulleting Jan. - Feb Vol. 3 No. 1.

The Green Dove.,(1999) "The Environment In the Next Millennium: Issues and Policies" No. 19 October

The Green Dove,. (2000)." The Environment in the New Millennium: Many Challenges". No. 20. Feb.

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Turner R. K., (1993). Principles and Practices; Sustainable Environmental Economics and Management. New York: Belhaven Press.

Water Resources Research Institute., (1988). "A Survey in the Mining Concession of the Ashanti Goldfields Corporation.

W.H.O., (1954). "Expert Committee on Environmental Sanitation," WHO Technical Report

Note 1.

Description	**Cu**	**Zn**	**Pb**	**Cd**	**Cr**	**Ni**	**Fe**	**Mn**	**A1**	**Hg**
Toxicity in solution to plants [(1)]	0.02	1.3	1.7	2.1	3.8	0.18	9.3	0.05	0.9	6.6
Toxicity in solution to fish [(2)]	0.02	1.3	1.7	2.1	120	30.0	250	100	1.5	0.06
Maximum concentration in drinking water [(3)]	1.5	15.0	0.1	0.01	0.05	-	1.0	0.5	-	0.001
Maximum concentration in water for farm animal [(4)]	0.5	25.0	0.1	0.05	1.0	-	-	-	5.0	0.01
Maximum concentration in irrigation water [(5)]	0.2	2.0	5.0	0.01	0.1	0.2	5.0	0.2	5.0	-

Table 1: Levels of Concentrations at which common heavy metals can be toxic to living organism (mg/1) .

(1) Concentration reducing growth (of roots of Lolium perenne) to 50% will vary with species

(2) Concentration reducing rainbow trout (Salmo gairdneri) to 50% after 48 hours.

(3) WHO (1971) recommendation

(4) EPA (1972) recommendations. Toxicities can be reduced by several factors, notably by the presence of calcium, phosphates, carbonates, hydroxides, organic matter and clay minerals.

Source: Ghana Environmental Action Plan (1994, P. 67).

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Note 2

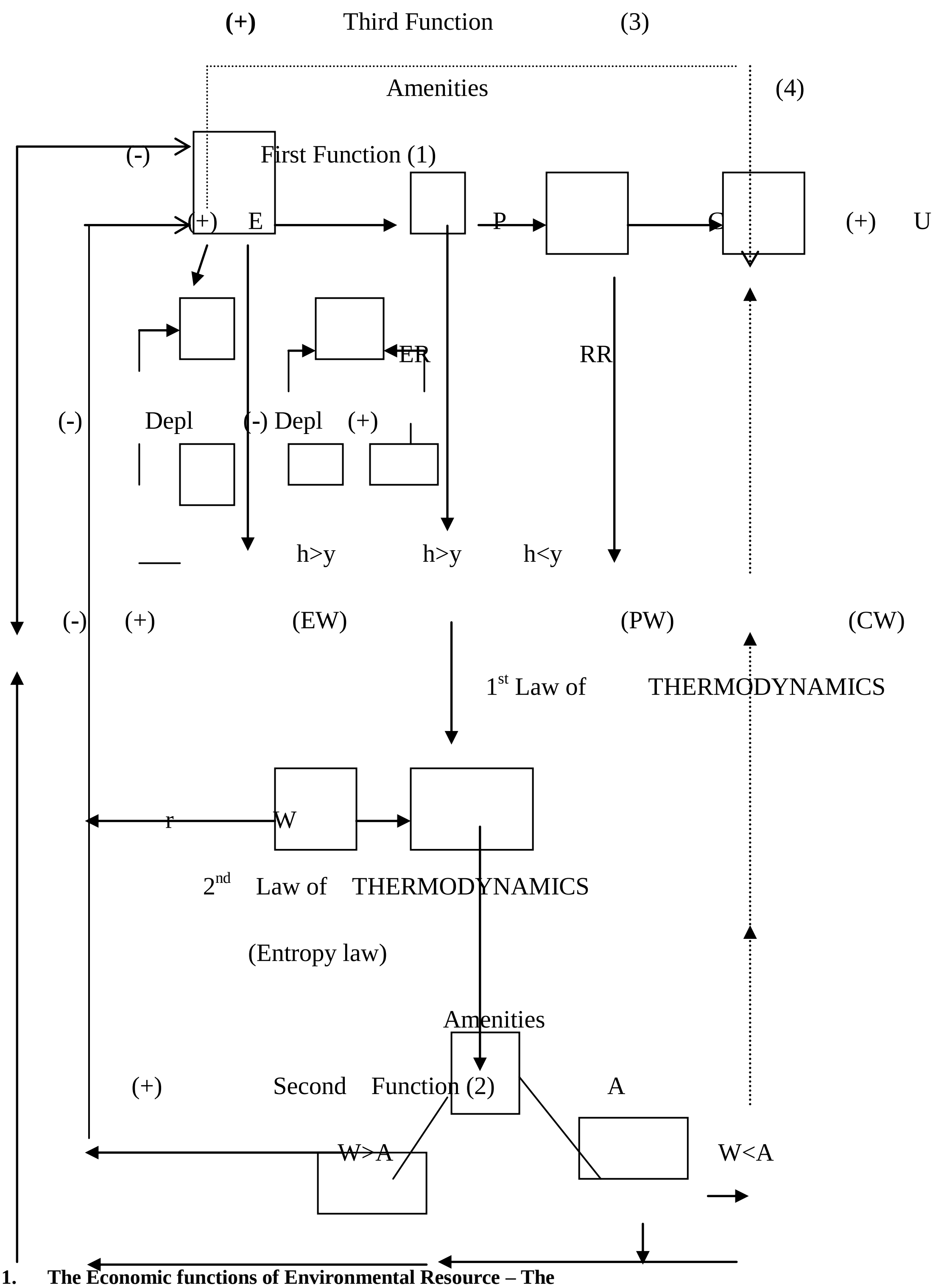

Fig. 1. The Economic functions of Environmental Resource – The Material Balance Model of Circular Economy.

Source: Pearce and Turner (1990, P. 247)