The Environmental Management Requirements Associated With Slag Deposition In The Iron And Steel Industry

By

Tanya Faber

Mini-Thesis Submitted In Partial Fulfillment Of The Requirements For The Degree

Magister Artium

In

Environmental Management

In The

Faculty Of Arts

At The

Rand Afrikaans University

Supervisor: J M Meeuwis

August 2000

TABLE OF CONTENTS

LIST OF FIGURES:

LIST OF TABLES:

1. INTRODUCTION

Internationally, steel is the largest metal industry and the second largest man made material industry in the world (Edington, 1997). This is understandable, as steel provides the world with a versatile and low cost engineering material, which is also widely accepted because of its ability to be recycled (Edington, 1997).

South Africa has large reserves of iron ore, which is used as the basic raw material in the iron and steel manufacturing process. This explains why the country is also home to a number of large iron and steel industries. In 1998 alone, 33 million tons of iron ore was mined in South Africa. In 1998 the country was rated the 21st largest steel producing country in the world by the International Iron and Steel Institute (IISI) having produced 7.7 million tons of crude steel (International Iron and Steel Institute (IISI), 1999). South Africa is also the largest steel producer in Africa, producing approximately 63 % of the continent's total steel production (South African Iron & Steel Institute (SAISI), 1999).

The iron and steel sector contributes to the well-being and growth of the South African economy by creating employment opportunities for a large percentage of the community and serving as an important generator of foreign exchange and investments, earning in excess of R 5,7 billion in 1997 (SAISI, 1999). In 1999 the basic iron and steel industry employed a total of 39 749 people (Statistics South Africa, 2000). In 1998 the steel industry contributed an estimated 6,9 % to the total value of manufacturing in South Africa (SAISI, 1999). A wide range of "environmental costs" is, however, also associated with the industry's use of environmental resources, either as input or output of the manufacturing process. The latter includes the disposal of solid waste by-products, including slag, and the environmental consequences associated with its disposal will be discussed later on in the thesis.

Following the growing international concern for the environment, a great number of general environmental problems were recently addressed in the South African law, resulting in a growth in the numbers and importance of environmental legislation (Barnard, 1999; Kidd, 1997). The South African environmental law, consisting of parliamentary- and provincial legislation, municipal by-laws, the principles of the common law and jurisprudence or case law, is aimed at regulating various important issues pertaining to the environment and of which the management of solid waste disposal forms an integral part (Barnard, 1999; Kidd, 1997). The disposal of solid waste, which includes the by-product slag produced by the iron and steel industries, forms a potential source of environmental pollution and is currently regulated in a fragmented and "haphazard and uncoordinated manner" (Fuggle & Rabie, 1992, p. 511), making access to various sources of law a difficult matter.

The South African environmental laws are generally regarded as "ineffective" owing to the lack of adequate enforcement and the effective administration and management of environmental quality. An ignorant steel industry can and will however still run the risk of criminal prosecution and civil actions being brought against them by third parties who are detrimentally affected by the environmental pollution caused by the slag disposal practices of an industry (Bethlehem & Goldblatt, 1997).

The main aim of this study is therefore to examine the potential impacts that indiscriminate slag disposal practices might have on the environment, as well as the environmental management principles and –tools developed to avoid or mitigate these impacts. The study will be of importance as it creates a better understanding of the broad basis of environmental laws specifically pertaining to slag disposal practices. It is furthermore aimed at limiting the risks of directors being criminally prosecuted and civil claims being instituted against a steel industry, while it stresses the general usefulness of departmental guidelines and -standards in achieving the goals of environmental management.

2. STATEMENT OF THE PROBLEM

Steel as a form of material has become a basic necessity in our modern day lives, increasing the demand for steel products on a worldwide scale. This caused steel industries to appear all over the world, grabbing the opportunity to satisfy this demand and hoping to claim a share of what turned out to be a prosperous market. Despite the benefits of economic and social upliftment associated with the steel market, the activities of the steel industry unavoidably also takes its toll on the environment. Slag is formed as a by-product of the iron- and steel manufacturing process and has the potential to impact significantly on the surrounding environment owing to its chemical properties and the large volumes which are generated and disposed of on dumps. Pollutants generated by slag dumps reach the natural resources, which include water, air and soil, and detrimentally affect the quality of these natural resources by compromising their fitness for use and by posing a risk to the health and well being of all forms of life. Leach ate, for example, infiltrates the soil layers to reach the groundwater regime and dust particles disperse in the air to affect the quality of air- and water resources. An explanation as to exactly how and in what way this happens will be dealt with in more detail later in this thesis.

The purpose of this study is therefore aimed at the following:

- To provide a background of the global demand for steel products and to identify the world's leading steel suppliers;
- To describe the study area by specifically referring to the leading steel manufacturers in South Africa;
- To elaborate on the typical uses of steel products in South Africa;
- To explain the process of iron- and steel manufacturing with the view of identifying the origin of slag;
- To identify the basic sources of slag and the typical quantities of slag produced;
- To identify the chemical substances associated with and originating from slag dumps and to describe the procedure used to analyse slag for its chemical components;
- To indicate in what way groundwater, surface water and soils are impacted on by pollutants originating from slag dumps;
- To describe how the quality of water from these water resources is lowered by the presence of the chemical substances associated with slag dumps, by affecting its fitness for domestic-, agricultural-, aquatic- and industrial use.
- To elaborate on how dust particles emanating from slag dumps can affect the quality of air in the immediate vicinity of the dumps;
- To explain how the general aesthetics of an area can be affected by the presence of slag dumps;

- To describe how government attempts to control or manage these impacts, by applying environmental management tools, such as environmental legislation, departmental guidelines and -standards;
- To describe how the Constitution, Environment Conservation Act and the National Environmental Management Act forms framework legislation within which the basic right to a healthy and pollution free environment can be secured;
- To explain how source and impact specific legislation and guidelines, such as the Water Act, section 19 of the Environment Conservation Act, the Atmospheric Pollution Prevention Act and the Department of Water Affairs & Forestry's Water Quality Guidelines and Waste Management Series are aimed at securing the quality and integrity of our natural resources;
- To explain how the common law, in the form of delictual claims and interdicts, provides a further tool in the hands of private individuals wanting to secure their rights to a healthy and clean environment.

3. DATA COLLECTION AND METHODOLOGY

In this study the collection of pre-existing data was limited mainly to the existing literature, as well as information communicated to the writer during site visits to large iron- and steel industries in both Vanderbijlpark and Newcastle. The literature more specifically includes journals on the iron- and steel industry, law journals, the reports from national and international co-ordinating bodies of the steel industry, academic textbooks, departmental guideline documents and -standards, Government Gazettes, case law and the internet. General information on local and international iron- and steel industries, their processes and statistical data were collected through reports and publications by the Industrial Development Corporation, the South African Iron and Steel Institute and the International Iron and Steel Institute. The contents of statutory law and the regulations promulgated under these acts, were accessed through Government Gazette's, while departmental guideline documents and –standards were obtained, in booklet form, from the various state departments concerned with the environment. The principles of the common law were over the years recorded by academics and applied by our courts, making these principles accessible through academic textbooks and the reported case law. The nature and the extent of pollution problems associated with the presence of slag dumps were communicated to the writer during the writer's involvement in services rendered to the steel industries on a consultation and contract basis.

A general shortfall in the data collection process was created by the reluctance of steel industries to publicly advertise their bad track records on environmental pollution caused by their steel-making activities. This includes the environmental pollution caused by the disposal of the by-product slag on dumps, which affects, inter alia, the quality of groundwater by rendering boreholes in the direct vicinity of the dumps unfit for use. As very little is published on this topic, scientific information on the nature and the extent of pollution caused by indiscriminate slag disposal practices, was gathered through personal communications with specialists in this field (C Nolte, Iscor, Vanderbijlpark; O Fourie, Ockie Fourie Toxicologists; C Wilson, Iscor, Newcastle). A further shortfall is the fact that environmental law, as in the case with other law, is subjectively interpreted and applied by practitioners, academics and courts of law. Because of its nature as a social science, the principles of law cannot be subjected to a verification process as is the case with other natural sciences.

In this study data is analysed and converted to sketch a general picture of the importance of steel products in our modern day life, and to identify the leading national and international steel producers providing the world in its need for steel products. An overview is given on the process of iron- and steel making, specifically aimed at indicating the origin of slag as a by-product of the process. The main objective of the study is aimed at identifying and elaborating on the impacts that slag disposal practices have on the environment's natural resources and its consumers, whether it be human, animal or aquatic. The principles of environmental management, as well as the mechanisms and tools utilised to address these impacts are also discussed.

4. THE WORLD'S LEADING STEEL PRODUCERS

Crude iron, which is a product of the blast furnace process and a forerunner in the steel manufacturing process, is produced at a global rate of 594 million tons annually while the world production of raw steel is estimated at 851 million tons a year (IISI, 1999). According to statistics published by the International Iron and Steel Institute (IISI), China, the USA and Japan are the world's leading steel manufacturers with China delivering 114.3 million metric tons of crude steel in 1998, followed by the USA at 97.7 million metric tons and Japan at 93.5 million metric tons. South Africa, ranking 21st on this list, produced about 7.7 million metric tons of crude steel in 1998 (IISI, 1999). The world's leading producers of steel are indicated below in table 1.

Table 1: The world's largest steel producing countries 1994 – 1998 (IISI, 1999)

RANK	1998	1997	1996	1995	1994
1. P.R. China	114.3	108.9	101.2	95.4	92.6
2. United States	97.7	98.5	95.5	95.2	91.2
3. Japan	93.5	104.5	98.8	101.6	98.3
4. F.R. Germany	44.7	45.0	39.8	42.1	40.8
5. Russia	42.5	48.4	49.3	51.6	48.8
6. R.o. Korea	40.0	42.6	38.9	36.8	33.7
7. Italy	26.1	25.8	24.3	27.8	26.2
8. Brazil	25.8	26.8	25.2	25.1	25.7
9. India	23.9	24.6	23.8	22.0	19.3
10. Ukraine	23.5	25.6	22.3	22.3	24.1
11. France	20.2	19.8	17.6	18.1	18.0
12. United Kingdom	17.3	18.5	18.0	17.6	17.3
13. Taiwan (R.o.C)	16.9	16.0	12.4	11.6	11.6
14. Canada	15.8	15.6	14.7	14.4	13.9
15. Spain	14.9	13.7	12.2	13.8	13.4
16. Mexico	14.1	14.3	13.2	12.1	10.3
17. Turkey	14.0	14.5	13.6	13.2	12.6
18. Belgium	11.6	10.8	10.8	11.6	11.3
19. Poland	10.0	11.6	10.4	11.9	11.1
20. Australia	8.8	8.8	8.4	8.5	8.4
21. South Africa	7.7	8.3	8.0	8.7	8.5

22. Czech Republic	6.5	6.8	6.5	7.2	7.1
23. Netherlands	6.4	6.6	6.3	6.4	6.2
24. Romania	6.4	6.7	6.1	6.6	5.8
25. Iran	5.6	6.3	5.4	4.7	4.5
26. Austria	5.3	5.2	4.4	5.0	4.4
27. Sweden	5.2	5.1	4.9	5.0	5.0
28. Argentina	4.3	4.2	4.1	3.6	3.3
29. Finland	3.9	3.7	3.3	3.2	3.4
30. Venezuela	3.7	4.0	3.9	3.6	3.5

5. STUDY AREA: THE LEADING SOUTH AFRICAN STEEL PRODUCERS

The location of local iron- and steel production plants are, over and above the economic advantages of a centralised location, mainly determined by the following factors:

- The availability of perennial water resources (e.g. rivers) for the abstraction of water needed in the manufacturing processes and the discharge of process waste water (e.g. Iscor's Newcastle plant is situated on the banks of the Ngagane river) (Wilson, 1999; personal communication)
- The availability of infrastructure in the form of railways and roads to connect the industries with its raw material suppliers, export harbours and the local market for iron- and steel products;
- The availability of energy in the form of electricity to conduct their activities.

The main producers of primary steel products in South Africa, their location and the range of their products are indicated below in table 2 (SAISI, 1998).

Table 2: Producers of primary steel products in South Africa. (SAISI, 1998)

Name of Company	Location	Range of Products
ISCOR LTD*	Vanderbijlpark Vereeniging Newcastle	Semi-finished, flat and profile products
Highveld Steel & Vanadium Corporateion LTD**	Witbank	Semi-finished, flat and profile products
Davsteel	Vanderbijlpark	Profile products
Scaw Metals LTD	Germiston	Semi-finished and profile products
Cape Town Iron & Steel Workd (PTY) LTD	Cape Town	Semi-finished and light bars
Columbus Stainless***	Middelburg (Mpumalanga)	Semi-finished and flat stainless steel product

* Iscor is the largest steel producer in South Africa and in Africa and is ranked the 30th largest steel producer in the world by the IISI in 1997.

** Highveld steel is the largest producer of vanadium in the world.

*** Columbus Stainless is the only stainless steel producer in South Africa.

The geographic location of these major steel-producing companies is indicated on the map. (figure 1)

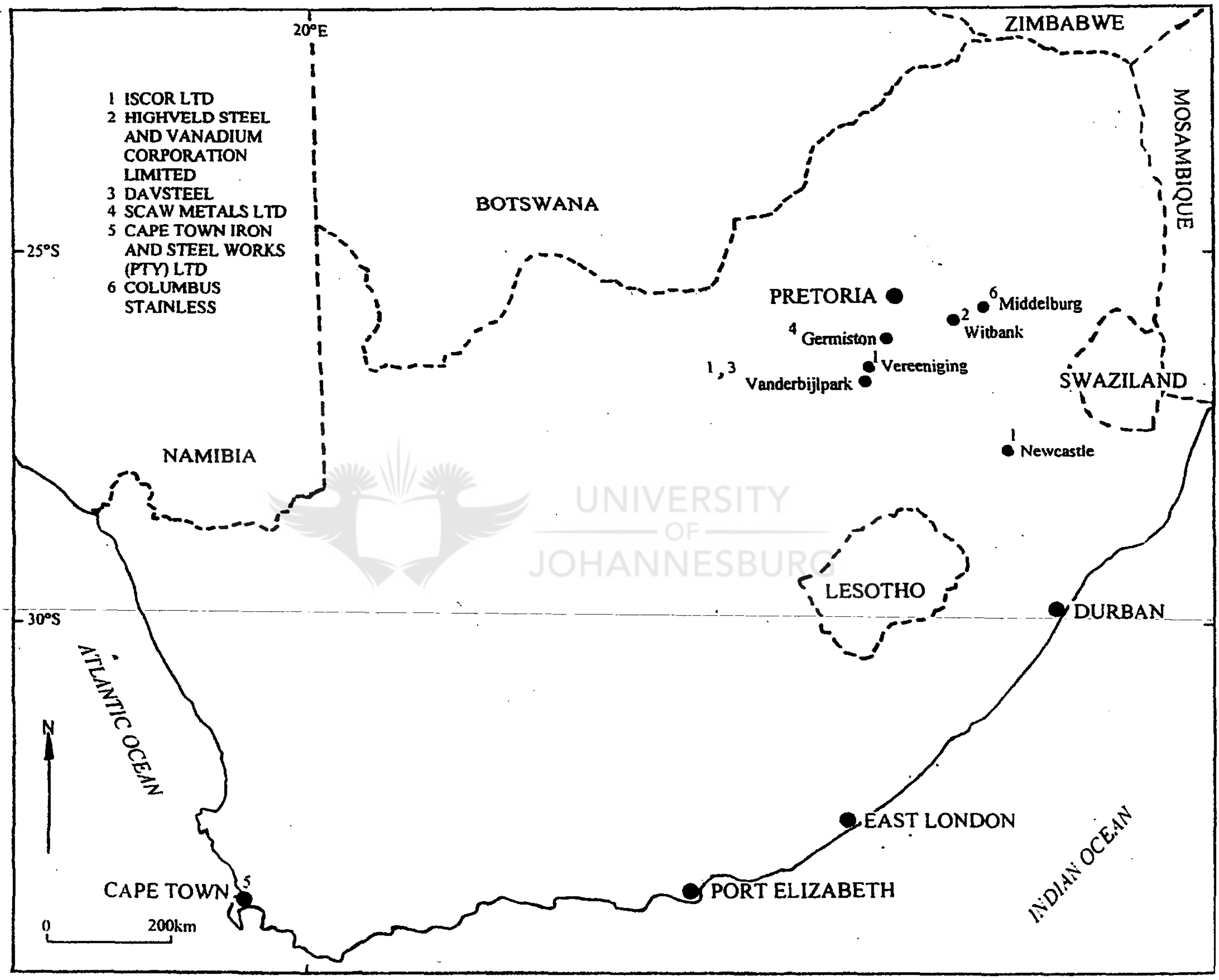


Figure 1: ***The location of the major steel producing industries in South Africa.***

According to the South African Iron and Steel Institute (SAISI), an estimated 43 % of steel is exported while about 57 % is consumed domestically (Industrial Development Corporation (IDC), 1999). In 1998 the approximately 3.165 million tons of steel exported earned in excess of R 5.7 billion in foreign exchange (SAISI, 1999). The various countries of destination of these export steel products are indicated below in figure 2.

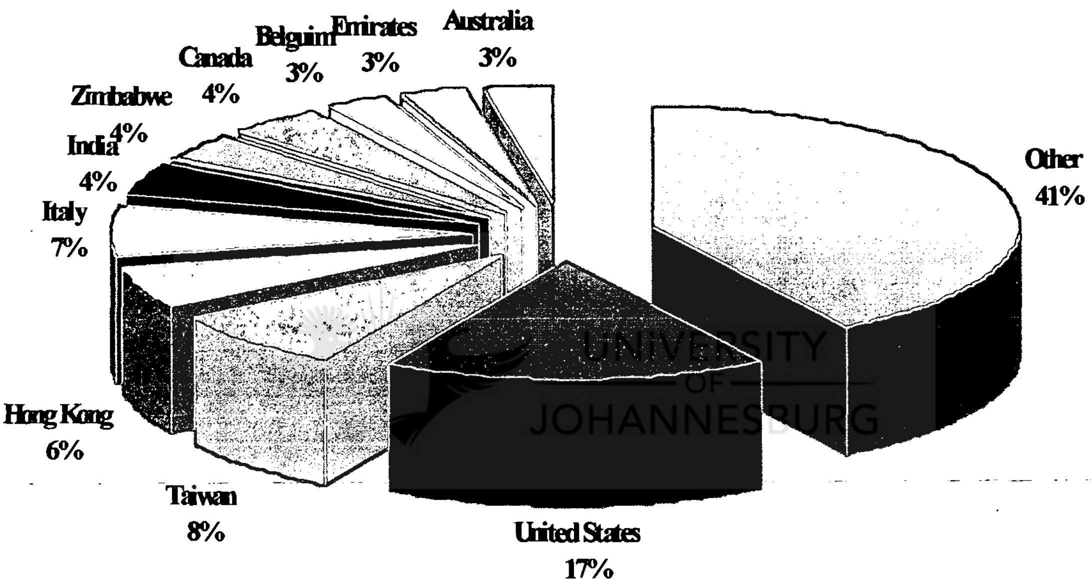


Figure 2: Countries of destination of export steel products (SAISI, 1999).

6. THE POPULAR USES OF STEEL PRODUCTS

Iron, usually further refined to steel during a process later described in more detail, is the most popular and widely used metal in the world and it provides for a great number of needs in our modern day life. Providing the world with a versatile and low cost engineering material, steel is a major material in the manufacturing of the following products (Edington, 1997):

- Cable and wire products and metal fasteners
- Pipe and tube
- Structural steel used for metal structures, prefabricated buildings, metal doors, windows and frames, shutters, fire escapes, gates etc.
- Motor vehicles and parts, including trailers and semi-trailers, motor vehicle parts and accessories for motor vehicles
- Packaging or containers used for packing or conveyance of goods
- White goods (household appliances) such as refrigerators, freezers, dishwashers, laundry equipment, cooking appliances, heaters and stoves
- Machinery of all types
- Other transport equipment for example building and repairing of ships and boats, railway locomotives etc.

The primary domestic steel purchases for the manufacturing of the above products are indicated in the figure below: (IDC, 1999).

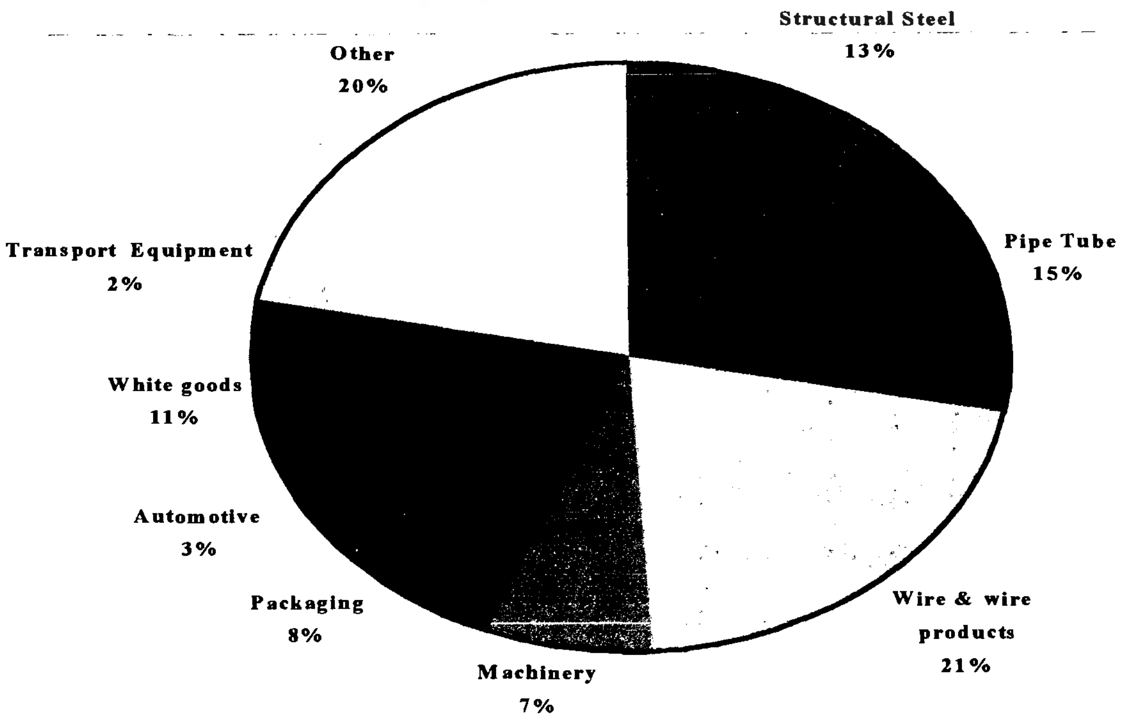


Figure 3: Primary domestic steel purchases for the period 1990 – 1998. (IDC, 1999)

7. THE IRON AND STEEL MANUFACTURING PROCESS AND THE FORMATION OF SLAG AS A SOLID WASTE BY-PRODUCT

7.1 Introduction

Great precision is required during the iron and steel manufacturing process as the different varieties of iron and steel products are all aimed at fitting a special need. The properties and composition of iron and steel will therefore depend on its end use and may vary from structural steel for the purpose of constructing bridges to heat-resistant alloy steel which is used in the nose cone of a rocket (IISI & UNEP, 1997). The complete process of transforming the basic raw materials, which includes iron ore, coal and limestone into steel products, is depicted below in *figure 4.*

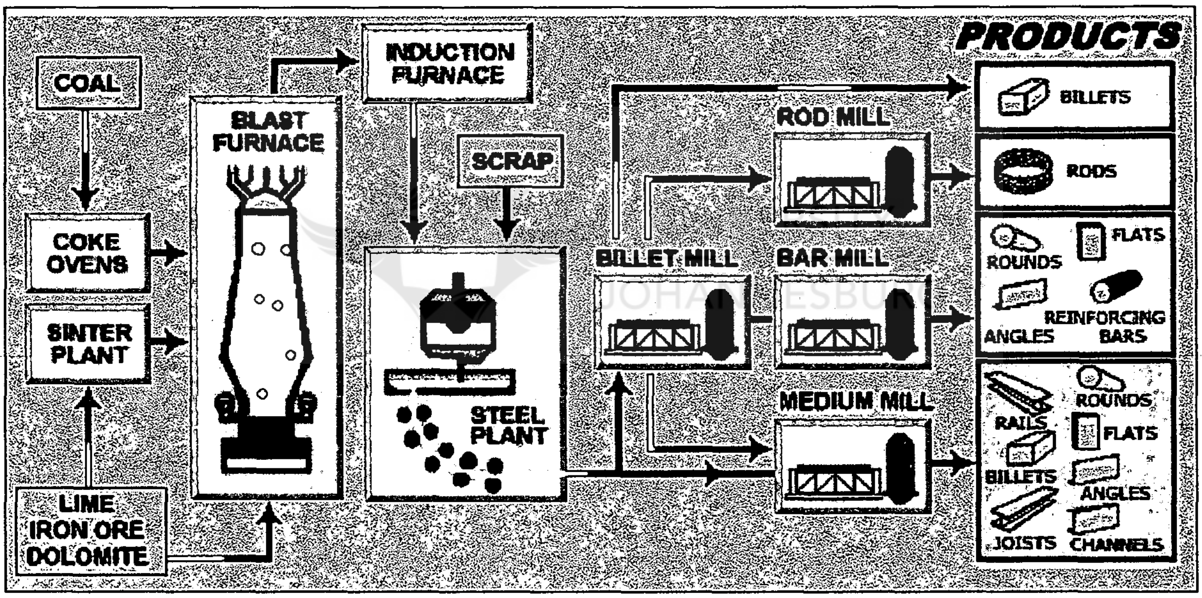


Figure 4: The Production Process
(Iscor, 1999)

7.2 Raw materials

Out of an input of various raw materials iron is produced which is subsequently converted into steel. The raw material input consists of iron ore, coal and limestone, but other materials such as recycled steel scrap, oils, chemicals and refining materials can also be included (IISI & UNEP, 1997; Prinsloo, 1993). The formula for the input of raw materials in the production of 1 ton steel is 1,5 ton iron ore, 0,75 ton metallurgical coke, 0,5 ton limestone and 3 tons of air (Prinsloo, 1993).

7.3 *Coke Making*

Metallurgical coke is the main source of energy during the iron production process, which takes place in the blast furnace ovens. Coal forms the basis of coke which is used to generate heat for the melting process in these ovens (IISI & UNEP, 1997; Prinsloo, 1993).

The coal is charged into a battery of coke ovens and the coke is then formed through a combustion process which takes place at temperatures as high as 1300°C and in the absence of oxygen (IISI & UNEP, 1997; Prinsloo, 1993). During this process volatile substances in the form of coke oven gas, oils and tars are driven off and these by-products can then be reworked into a variety of other products (e.g. benzene, tar and sulphur) (IISI & UNEP, 1997; Prinsloo, 1993).

7.4 *Sintering*

Materials such as coke breeze and iron ore fines, both too fine to be used directly in the blast furnace oven, are heated to a semi-molten mass. These solidified, porous pieces of sinter are now large enough to be recycled in the blast furnace during the process of iron production (IISI & UNEP, 1997, Prinsloo, 1993).

7.5 *The manufacturing of iron*

The manufacturing of iron serves as a forerunner in the steel production process as this basic metal is later on further refined to form steel.

The iron making process is depicted in *figure 5.*

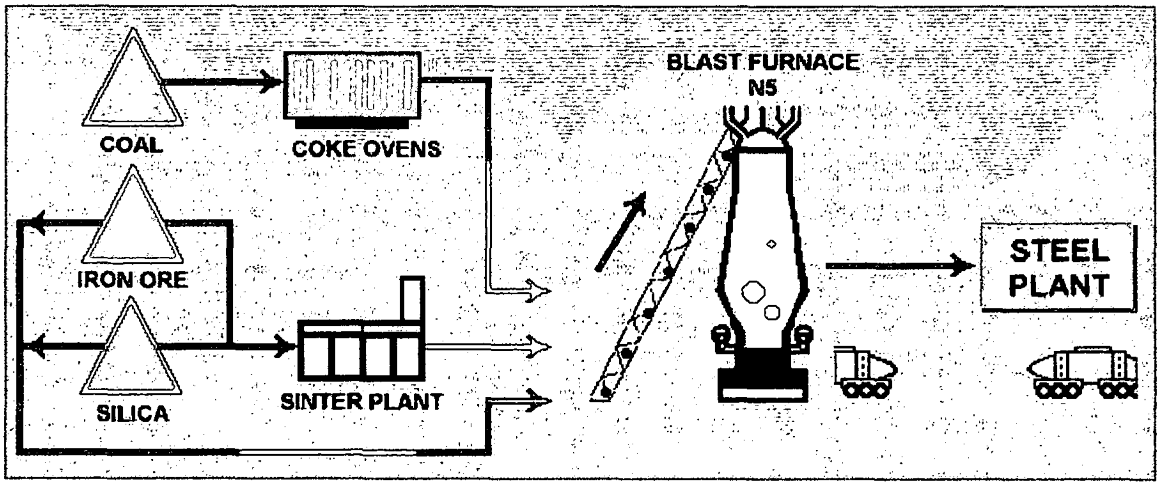


Figure 5: The manufacturing of iron
(Iscor, 1999)

Iron is melted in the blast fumace to form crude or pig iron. During this process iron ore, pieces of sinter, coke, limestone, dolomite or silica are charged into the top of the blast fumace oven by way of a skip car. Pre-heated hot air, reaching approximately 1000°C, is blown into the blast fumace by means of tuyeres. The hot air causes the coke to bum and release energy in the form of heat, which melts the iron ore. Temperatures inside the fumace may reach a height of 1 650°C or higher. Carbon monoxide is released during the buming of coke and combines with the oxygen in the iron ore to release the molten iron from the ore. Dolomite, limestone and silica function as a flux, which purifies the iron. The limestone and dolomite then combine with the melted impurities to form the by-product slag. The liquid iron sinks to the bottom of the fumace where it is removed through a tap. Because slag is lighter than iron, the molten slag layer floats on top of the melted iron and is subsequently removed and cooled down (Anon, 1998; IISI & UNEP, 1997; Prinsloo, 1993). Granulated slag is formed when liquid slag from the blast furnace processes is poured into a high-pressure stream of water to form a sand-like material. This is usually sold for use in road construction or cement production (IISI & UNEP, 1997).

7.6 *Casting process*

Casting takes place when white-hot molten iron is drawn from the tap hole and dropped into an iron ladle, in the form of a pot or a hot-metal car, below the casting platform. Iron is subsequently poured into the moulds from the pot, while the car is being used to keep iron hot and liquid while transporting it to the steel making process.

7.7 *Steel manufacturing*

The steel manufacturing process is explained below in *figure 6.*

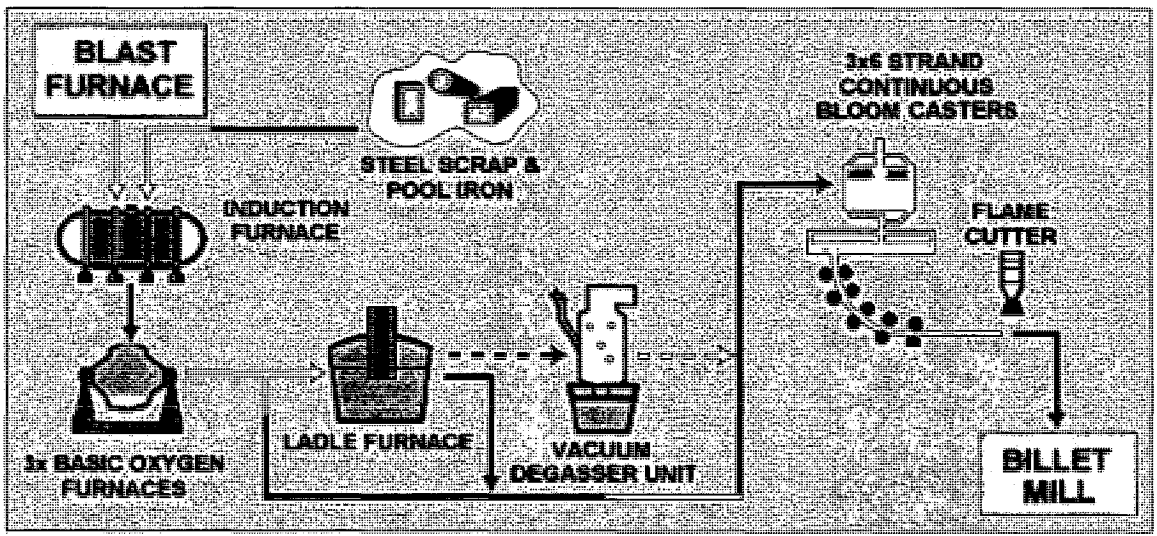


Figure 6: The steel manufacturing process
(Iscor, 1999)

The steel production process can be seen as a procedure of further refining. During this process the carbon content of iron, which affects the mechanical and physical characteristics of the products, is reduced to an acceptable level and other impurities are removed (IISI & UNEP, 1997; Prinsloo, 1993). Two main grades of steel can be distinguished, namely carbon and alloy steels. Carbon steels contain iron, carbon and manganese, of which carbon is the prominent element. Alloy steels have carbon steel as a basis, but with substances like nickel, chromium or molybdenum added to change its character.

There are currently two process routes, which can be followed in the manufacturing of steel, namely the basic oxygen furnace route and the electric arc furnace route. This differentiation is determined by the type of iron bearing feedstock used. During the basic oxygen furnace process the input material consists mainly of iron ore and a smaller percentage of steel scrap, while in the case of the electric arc furnace process mainly scrap steel is used (IISI & UNEP, 1997).

During the basic oxygen furnace process route gases like nitrogen and argon are blown through the bottom of the oven, while high-purity oxygen is blown at supersonic speed through the top of the oven to burn out any impurities in the material (IISI & UNEP, 1997; Prinsloo, 1993). Such a blow cycle normally lasts for about 20 minutes. In this blast process the carbon in the iron is oxidised and released as carbon monoxide and carbon dioxide gases, reducing the carbon content from the steel product from approximately 4% to about 0.2% (IISI & UNEP, 1997). Dolomite, silica and lime act as fluxes and react with the unwanted impurities to form a liquid slag. The liquid slag is then poured off the molten steel into slag pots and transported to quenching pits where the slag is sprayed with water in order to cool it off (IISI & UNEP, 1997; Prinsloo, 1993). Alternatively the steel manufacturing process can follow the electric arc furnace route, which means that an electrical stream is used through electrodes protruding the furnace roof and generating heat for the melting process (IISI&UNEP, 1997; Prinsloo, 1993).

The secondary refining process of the liquid steel includes vacuum degassing and ladle metallurgical facilities and is aimed at preparing the steel for the casting process. During the process of vacuum degassing, gaseous impurities such as hydrogen and oxygen are removed from the steel. The ladle metallurgical facilities process is used to change the metallurgical composition of steel by adding specific fero-alloys to it (IISI & UNEP, 1997).

Liquid steel is then cast into slabs, blooms or billets depending on the final steel product. These steel slabs, blooms or billets are subsequently rolled into various finished or semi-finished products such as sheets, plates, bars, rods, pipes and various structural shapes (Anon, 1998; IISI & UNEP, 1997; Prinsloo, 1993).

7.8 The by-product slag

The presence of mountainous piles of slag on the production sites of the iron- and steel industries is a distinct feature of these industries. Slag's can generally be described as non-metallic by products of metallurgical operations, which include the manufacturing of iron and steel, and consist primarily of calcium, magnesium and aluminium silicates in various combinations (IISI&UNEP, 1997; Prinsloo, 1993).

Slags are co-products of both the iron- and steel making processes. During these processes dolomite and limestone are used as fluxing agents to purify the metal by combining with the unwanted impurities. When the fluxing agents dissociate into calcium and magnesium oxides, these oxides combine with silica and alumina to form slag (IISI & UNEP, 1997; Prinsloo, 1993).

The type of slag, which is formed, and its chemical composition depend mainly on the specific cooling method used, as well as the chemistry of the raw materials used. On an integrated steel-manufacturing site the main distinction is made between iron slags, originating from the processes taking place in the blast furnace, and steel slags, originating from the basic oxygen furnace and electric arc furnace processes. Blast furnace slag is characterised by its granulated form and is formed when molten slag is quenched by the application of high-pressure water (IISI & UNEP, 1997). Blast furnace slag is classified as general waste because of the minor and insignificant impact it poses on the environment (Fourie, 1999; personal communication; Nolte, 2000; personal communication).

Steel slags, consisting of basic oxygen furnace and electric arc furnace slags, are normally classified as hazardous because of the hazardous components introduced via the scrap metal added during the melting process (Fourie, 1999; personal communication; Nolte, 2000; personal communication). Molten steel slags are normally cooled in water to form a more porous and lightweight type of slag (IISI & UNEP, 1997)

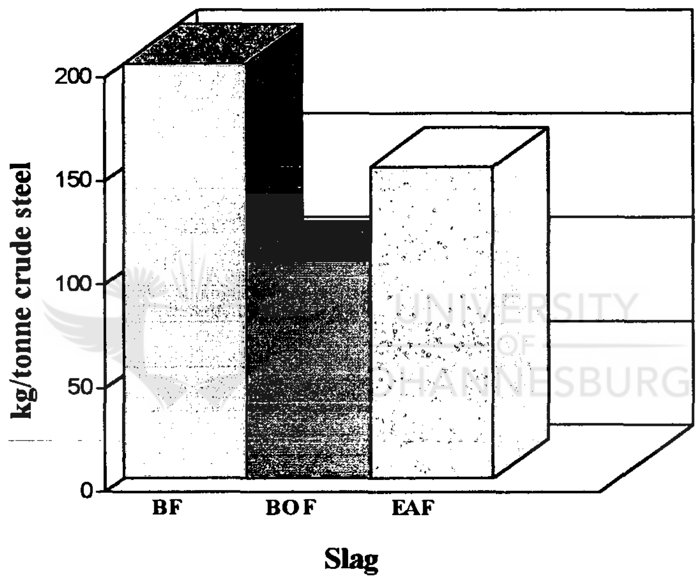
Much of the slag output is being recycled and utilised in a number of ways. Slags are especially suitable for use in road construction and concrete or for conversion into cement (IISI & UNEP, 1997).

The chemical composition of slag is discussed later on under paragraph 9.2 and also dictates its main uses. Slags of basic calcic composition are, for example, volumetrically unstable and their use in construction and road making will be restricted because of its tendency to expand and disrupt with time (Gold ring & Juckes, 1997). The use of ores rich in phosphor results in highly phosphoric slags, which could be, used as agricultural fertiliser (Gold ring & Juckes, 1997).

Although significant quantities of slag are being recycled, substantial amounts are still being dumped on the premises of steel production plants, often admixed with other by-products from the iron- and steel making process (e.g. tar from the coke ovens) (Gold ring & Juckes, 1997). The chemical substances and impurities contained in slag will determine its potential to impact on the environment when discarded in the form of slag dumps. The formation and chemical composition of leach ate originating from these dumps, as well as its impact on the environment will be discussed in more detail under paragraph 9 in the thesis.

8. PRIMARY SOURCES OF SLAG AND TYPICAL VOLUMES GENERATED

The by-product slag is formed mainly through the processes taking place in the blast furnace, the basic oxygen furnace and the electric arc furnaces, with blast furnace slag accounting for 54 %, steel-making slags for 21 % and special slags from pre-treatments for a small percentage by volume of all integrated site by-products (IISI & UNEP, 1997). According to the International Iron and Steel Institute (IISI & UNEP, 1997) approximately 455 kg slag is generated for every one ton of crude steel produced (IISI, 1997). The contribution in volume towards this figure by the processes of the blast furnace, basic oxygen and electric arc furnaces is indicated below in *figure* 7.



BF	:	Blast Furnace
BOF	:	Basic Oxygen Furnace
EAF	:	Electric Arc Furnace

Figure 7: Composition of by-products and waste in an integrated steel plant. (IISI, 1997)

Table 3 indicates the typical volumes of slag produced in South Africa for the years between 1996 – 1998 by the primary sources of slag, namely the blast furnaces, basic oxygen furnaces and electric arc furnaces.

Table 3 : Volumes of slag produced 1996 – 1998
(IISI, 1997 & SAISI, 1999)

Plant Description	**Volume of slag per 1 ton of crude steel**	**Percentage of slag produced per 1 ton (10116kg) of crude steel**	**Tons slag produced in 1996**	**Tons slag produced in 1997**	**Tons slag produced in 1998**
Integrated Site	455 kg	46%	3 680 000 tons	3 818 000 tons	3 542 000 tons
Blast Furnace	200 kg	20%	736 000 tons	763 600 tons	708 400 tons
Electric Arc Furnace	150 kg	15%	552 000 tons	572 700 tons	531 300 tons
Basic Oxygen Furnace	115 kg	11%	404 800 tons	419 980 tons	389 620 tons

9. THE IMPACT OF SLAG DUMPS ON THE ENVIRONMENT

The presence of slag dumps on the site of a steel manufacturing plant creates a source of potential environmental pollution and can affect the quality of water resources, soil, air and the general aesthetic value of an area. Leach ate generated through the percolation of rainwater through a slag dump and run-off water from the surface of the dumps contain chemical constituents (e.g. sulphur, phosphorus and lead) which, in large quantities, contaminate surface- and groundwater resources. The quality of these water resources is affected by rendering it unfit for a variety of uses which include domestic-, agricultural- and industrial use. Under windy conditions dust is generated from uncovered dumps which causes a nuisance and poses a health hazard to residents in its immediate vicinity. The overall aesthetic value of the area is also spoiled by the presence of these dumps and the clouds of dust generated from these dumps.

9.1 Chemical substances originating from the slag dumps

Slag as a solid waste by-product can only be effectively managed once its chemical composition and the concentration and quantity of such chemical substances are known. The information will only be known through the accurate analysis of samples taken from a slag dump (DWAF, 1998).

The Department of Water Affairs and Forestry (DWAF), in its document on the Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, sets out certain principles to ensure a good analytical practice of waste samples. It is required that a recognised and established documented method applicable to a specific sample type be used. These recognised analytical methods are stipulated in the DWAF's Minimum Requirements document (DWAF, 1998). Furthermore the analytical procedure should be fully documented and contain, *inter alia*, a description of the sample preparation, calibration standards, analysis procedure and the quality control measures taken. All analytical data must be supervised by a suitably qualified person (DWAF, 1998).

It is important to realise that not all the chemical substances associated with slag disposal will necessarily leach out and pollute the environment. The Toxicity Characteristic Leaching Procedure (TCLP Test) and Acid Rain tests are therefore used to determine the amount of chemical substances that will leach out of slag dumps to eventually reach groundwater- and surface water resources. During both tests the dissolving action of leach ate formed in a slag dump is simulated. While the TCLP test is applicable in cases where organic (e.g. phenols, solvents etc) and inorganic (e.g. lead, zinc etc) wastes are co-disposed, the Acid Rain test will apply when inorganic wastes are mono-disposed off (DWAF, 1998). It is necessary to distinguish between these tests as slags were in the past co-disposed with coke oven tar (a phenol) as a result of poor management practices.

9.2 The chemical substances associated with slag dumps

Analysis of samples taken from slag dumps generally indicates the presence of chemical substances of particular concern to the environment (table 4). These substances only become a cause of real concern once its concentration in a water body exceeds the Target Water Quality Range as determined by the DWAF in its Water Quality Guidelines (DWAF, 1996). The Target Water Quality Range reflects the ideal or acceptable concentrations of chemical substances in water, without any known significant impacts on the various uses of a water body. These include domestic-, agricultural-, industrial and aquatic use and the Target Water Quality Range will vary according to the type of water use (DWAF, 1996). The Target Water Quality Range for the various water uses are indicated below in table 4.

*Table 4: **Chemical substances contained in slag and the Target Water Quality Range for the various water uses (DWAF, 1998)***

		Domestic	Aquatic	Agricultural / Livestock Watering	Agricultural Irrigation	Industrial "Cooling Water"	Industrial "Steam Generation"	Industrial "Process Water	Industrial "Waste Water"
Aluminium	Al	0-0.15 mg/l	5-10 µg/l	0-5 mg/l	-	-	-	-	-
Argon	Ar	-	-	-	-	-	-	-	-
Calcium Oxide	CaO	0-32 mg/l	-	0-1000 mg/l	-	-	-	-	-
Fluor-spar	CaF_2	0-1.0 mg/l	<= 750 µg/l	0-2 mg/l	-	-	-	-	-
Iron	Fe	0-0.1 mg/l	<= 10% of background dissolved iron concentratio n	0-10 mg/l	<= 5.0 mg/l	0.0-0.1 mg/l	0.0-0.2 mg/l	0.0-0.3 mg/l	0.0-10.0 mg/l
Lead	Ph	0-10µg/l	Soft-medium water hardness: <= 0.2-0.5 µg/l Hard to very hard: <= 1.0-1.2 µg/l	0-0.1 mg/l	<= 0.2 mg/l	-	-	-	-
Magnesium Oxide	MgO	0-30 mg/l	-	0-500 mg/l	-	-	-	-	-
Manganese Oxide	MnO	0-0.05 mg/l	180 µg/l	0-10 mg/l	<= 0.02 mg/l	0.0-0.05 mg/l	0.0-0.1 mg/l	0.0-0.2 mg/l	0.0-10.0 mg/l
Nickel	Ni	-	-	0-1 mg/l	<= 0.2 mg/l	-	-	-	-
Phosphorus	P	-	<= 15% of the concentratio n in water	-	-	-	-	-	-
Selenium	Se	0-20 µg/l	<= 2 µg/l	0-50 µg/l	<= 0.02 mg/l	-	-	-	-
Silicon dioxide	SiO_2	-	-	-	-	-	-	-	-
Sulphur	S	0-200 mg/l	-	0-1000 mg/l	-	0-30 mg/l	0-80 mg/l	0-200 mg/l	0-500 mg/l

Goldring *et al*, 1997; Ji *et al*, 1998; Meraikib, 1997; Meraikib, 1997; Mitchell *et al*, 1997; Nzotta *et al*, 1997; Nzotta *et al,* 1997; Shahbazian *et al*, 1999; Shahbazian *et al*, 1999), Susa *et al*, 1997.

The DWAF has researched the implications and the impacts on domestic-, agricultural-, industrial- and aquatic use of water where chemical substances exceed the Target Water Quality Range and these impacts will subsequently be discussed below.

9.3 Water pollution

The water resources under threat of being polluted by leach ate and run-off water from slag dumps include the groundwater- and surface water resources. These water sources can be utilised for a variety of uses which include domestic use, agricultural use and industrial use. Surface water resources also sustain aquatic life and the ecological integrity of an area.

9.3.1 Groundwater pollution

To have a meaningful understanding of exactly how the presence of slag dumps may have an impact on the quality of groundwater, it is important to shed some light on the nature of sub-surface material and aquifers. Groundwater is contained in water-bearing rocks called aquifers and accounts for less than one third of one percent of the Earth's water resources (Miller, 1996). It is, however, still regarded as an important source of fresh water supply as it provides a safe and steady supply of drinking water (Miller, 1996). Groundwater supplies, extracted through boreholes, also provide in the need for basic domestic- and agricultural use.

Groundwater is polluted when leach ate, containing various chemical substances and formed through the percolation of rainwater through the slag dump, infiltrates the soil layers and percolates downward into the ground to reach the sub-surface aquifers (Miller, 1996; Cunningham & Siago, 1999). The groundwater levels, elevated by the presence of run-off collection dams at or near the toe of the dumps, may further contribute towards the migration of leach ate to the groundwater regime resulting in the contamination of groundwater with a variety of chemical substances. The movement of groundwater in the aquifer happens very slowly through a network of tiny cracks and intergranular spaces in the rocks at a speed of seldom more than 10 meters a day, but even as slow as less than one meter a year (Cunningham & Siago, 1997; Shearer, 1999). The slow movement of groundwater in aquifers, together with the normally long history of pollution by the steel industries makes the rehabilitation of aquifers a long and costly operation and an impossible task (Chapelle, 1997). Because the groundwater flow is so slow, contaminants originating from the slag dumps will not be easily diluted or dispersed and will cause the aquifer to be cleansed very slowly or be permanently polluted (Chapelle, 1997; Cunningham & Siago, 1997). The much smaller populations of decomposing bacteria present in groundwater and its colder temperature slows down the decomposition of degradable waste while non-degradable waste will be permanently present (Miller, 1996). The risk of groundwater pollution will be more significant when no interception measures are in place to cut off migrating leach ate or if such measures are inefficient (Cunningham & Siago, 1997).

9.3.2 Surface water pollution

Rainwater infiltrates slag dumps and comes into intimate contact with the dump material, increasing the load of chemical substances in leach ate, run-off and seepage water. This water carries loads of sulphur, aluminium, lead etc. which migrates to nearby dams, channels, streams, rivers and wetlands and affects the quality of the water and its fitness for use by elevating the levels of certain chemical substances above the Target Values as set down by the Department of Water Affairs & Forestry (DWAF). The reasons for setting these Target Water Quality Range and how this applies to slag dumps will be further elaborated on under 9.3.4 below.

Run-off and seepage water from the slag dumps is, for this reason, not suitable for discharge into the natural water resources without having been treated first. In accordance with good pollution control practises proper run-off controls should be placed around slag dumps and dams are normally constructed at the toes of these dumps in an attempt to collect seepage and run-off water and to promote the evaporation of polluted water. Polluted water is subsequently diverted to the water treatment plant where it is chemically treated before its release back into a water body (Nolte, 2000; Personal Communication).

9.3.3 Impacts on soils and vegetation

The leaking, overflowing or absence of seepage and run-off collection dams around slag dumps results in the flooding of the adjacent land with polluted water originating from the slag dumps, posing risks to grazing and irrigation land (IISI & UNEP, 1997). The flocculation of these soils by the migration of salts will result in soils losing their moisture retention capacities and eventually lead to decreases in crop yields and a reduction in the carrying capacity of agricultural land. Irrigation with contaminated surface water will have similar impacts on irrigation land (Miller, 1996).

9.3.4 The effects caused by the presence of chemical substances associated with the disposal of slag on the various forms of water use

Local residents, farmers and industries staying in the vicinity of a steel industry's slag disposal area, utilise groundwater and surface water resources to provide for the need of water for domestic-, agricultural- and industrial use. The aquatic environment is also a recognised "user" of these water resources (DWAF, 1996).

Seepage and run-off water originating from slag dumps contain, *inter alia*, high levels of aluminium, lead, iron, sulphur, phosphorus, fluoride, magnesium and manganese. When this contaminated water reaches surface- and groundwater resources, it elevates the concentrations of substances already present in the receiving water body from levels acceptable or tolerable to its users to levels which are unacceptable and renders water completely unfit for use. It follows that the quality of these water resources is altered by chemical pollutants originating from slag dumps, impacting on the various users of the water resources, their health and products. The DWAF developed the Target Water Quality Range in an attempt to maintain the quality of the country's water resources and its fitness for a specific use, whether it be domestic-, agricultural-, industrial-, recreational- or aquatic use. The effects caused by the presence of the chemical substances associated with the disposal of slag on the various forms of water use are discussed below.

- **Domestic use**

Polluted run-off and seepage water from slag dumps elevates the levels of calcium, magnesium, aluminium, iron and manganese in water resources used for domestic purposes and may cause substantial damage to household equipment. The presence of high concentrations of calcium and magnesium, for example, leads to the formation of scaling in household heating appliances such as kettles, urns, geysers, pipes and elements, while the lathering of soap is impaired leading to the excessive consumption of soap. High traces of aluminium, iron and manganese, associated with the disposal of slag on dumps, are responsible for the discolouration of water supplies and staining of enamelled surfaces such as baths and basins, plumbing fixtures and laundry (DWAF, 1996).

Polluted water from slag dumps increases the concentrations of aluminium, fluoride, iron, lead and manganese in drinking water and can pose detrimental consequences on human health (DWAF, 1996). This is especially the case where local residents, staying in the immediate vicinity of large slag dumps, utilise boreholes as the main source of water supply. Although no clear medical evidence exists to proof that the use of drinking water polluted by slag dumps will have significant impacts on human or animal health, certain consequences can however be expected and will subsequently be dealt with.

Prolonged exposure to high concentrations of aluminium, lead and manganese can cause permanent neurological disorders in human consumers, for example Alzheimer's disease in the case of prolonged exposure to aluminium and Parkinson's disease in the case of exposure to manganese. Lead contamination is well associated with slag dumps and the continuous exposure to low concentrations of lead is associated with neurological impairment in foetuses and young children, behavioral changes and impaired performance in intelligence quotient tests. In adults the effects take the form of anaemia and acute abdominal pain. High dosis of fluoride interfere with bone formation and metabolism, leaving chronic damage to kidneys and the thyroid gland, while the more acute toxic effects include injury to the liver and heart muscle tissues. The excessive ingestion of iron leads to the accumulation of iron in tissues, which may cause damage to the organs. Slimy coatings in plumbing, caused by the presence of iron oxidising bacteria, attracts microbial deposits which can further pose a risk to human health. High concentrations of sulphate in drinking water renders water salty or bitter, causing diarrhoea on consumption thereof and corrosion in distribution systems (DWAF, 1996).

In a recent civil action brought against the steel giant Iscor by the owners of smallholdings adjacent to the Vanderbijlpark plant, allegations were made of instances where the health of certain residents were affected by the use of groundwater polluted by slag dumps. As the matter was eventually settled out of court, no medical evidence was lead to prove that the alleged kidney failures and teeth deformities resulted from the use of the contaminated water (Nolte, 2000; Personal communication).

- **Agricultural use**

A further detrimental impact associated with the pollution caused by slag dumps arises when contaminated surface and groundwater resources are utilised for the purpose of livestock watering and to irrigate crops and agricultural soils. Polluted water from slag dumps elevates the levels of the chemical substances aluminium, fluoride, iron, lead, manganese, nickel and selenium in a water body and affects the crops and soils, as well as the health of livestock being watered with contaminated water (DWAF, 1996). Crop yield and the quality of crops produced can be affected by the uptake of large amounts of these substances by plant roots. High concentrations of iron in irrigation water derived from polluted surface water sources can, for example, coat the leaves of plants and fruits with iron oxide spots and interfere with normal photosynthesis, transpiration and respiration in plants. Concentrations of lead and selenium accumulate in the roots, leaves and fruit of plants. Although it does not pose a significant danger to the plant itself, it is however potentially hazardous to its human and animal consumers (DWAF, 1996).

Aluminium, fluoride, lead, magnesium, sulphate and iron are the substances generally associated with the disposal of slag and can cause health problems in livestock watered from water resources contaminated in this way (DWAF, 1996). High levels of aluminium in water lead to a decreased availability of absorbable iron phosphate complexes in livestock, while large amounts of fluoride can cause tooth damage, crippling because of bone lesions, loss of appetite, decreased feed intake and reduced performance in livestock. Iron, though essential for normal functioning, can also be harmful in high concentrations and cause symptoms of iron toxaemia, which include vomiting, diarrhoea, acidosis, shock, respiratory failure and damage to the liver and pancreas of animals. Lead poisoning in animals is acute and the symptoms include excitability, frothing from the mouth, lack of hind limb co-ordination, muscular tremors and convulsions, anorexia, diarrhoea or constipation and respiratory distress. Excessive levels of magnesium and sulphate can cause diarrhoea in stock, especially in cases where livestock are not adapted to sulphate, which renders water unpalatable. While high levels of magnesium can cause lethargy, loss of co-ordination and decreased feed intake, excessive sulphate in drinking water may lead to poor productivity in animals (DWAF, 1996).

- **Aquatic ecosystems**

The effects of certain chemical substances on the health of natural ecosystems and mortalities in certain aquatic species depends on factors like its concentration, the length of exposure and the previous acclimation in fish species. The migration of polluted water originating from slag dumps increases the concentrations of substances like aluminium, iron, lead, manganese, selenium, fluoride and sulphide in a water body and disturbs this delicate balance in the aquatic environment (DWAF, 1996). When concentrations of these chemical substances are elevated in such a way that the Target Water Quality Range for the specific chemical substance is exceeded, the health and existence of aquatic life is sure to be affected in one or more of the following ways:

Aluminium, for example, accumulates in the tissues of aquatic organisms, causing a decrease in locomotive activities, hyperventilation, the clogging of mucus of gills, anaemia and an increased susceptibility to disease. The development and hatching of eggs may also be influenced by high levels of aluminium in aquatic environments. Iron precipitates on the gills of fish or incubating eggs may interfere with the transport of oxygen while dissolved iron may further cause respiratory distress by damaging the gills of fish. Lead, as in the case of the other consumers of water with a high lead content, can be acutely toxic to aquatic life and could introduce disorders like interference with sugar metabolism and haemoglobin synthesis. Lead also changes the immune system of fish making it more susceptible to disease and can cause spinal deformities after prolonged exposure. High concentrations of manganese interferes with the central nervous systems of vertebrates, disrupt the regulation of sodium in fish and accumulates in the liver of fish. Although aquatic organisms are seldom exposed to toxic levels of selenium in water, their consumption of plants with accumulated amounts of selenium may be toxic and result in haematological changes, impaired reproduction and mortalities in fish. Long-term exposure to sulphide may lead to reduced reproductivity due to reduced egg deposition and the high incidence of infertile eggs, while acute toxic effects include damage to the gills of fish interfering with respiration. When exposed to fluoride over long periods, skeletal fluorosis may occur in fish (DWAF, 1996).

9.4 Dust pollution

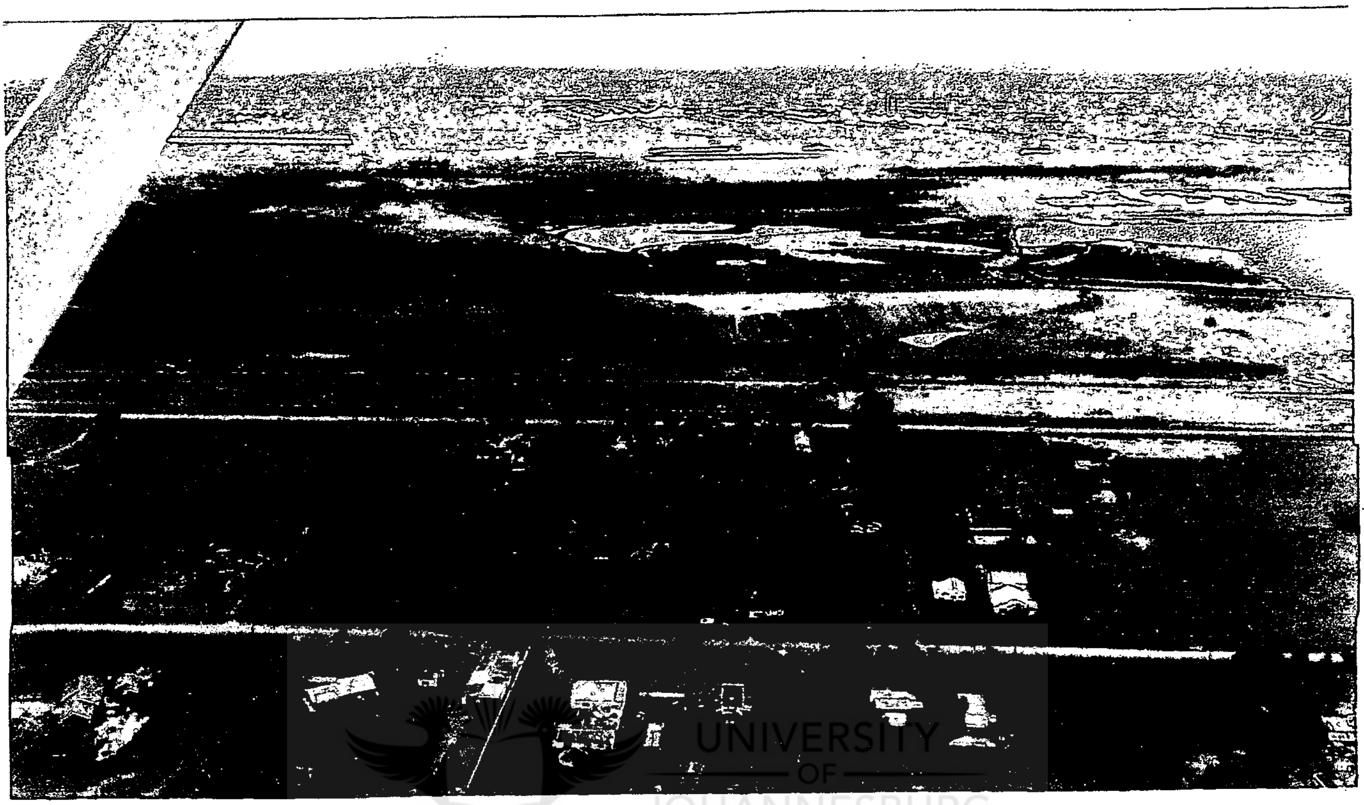
The air is polluted with particulate matter when fugitive dust is generated by high winds around slag dumps and the on- and offloading of slag material for reclamation purposes. Dust emissions are normally restricted to the local and immediate area around slag dumps and may create a nuisance and health hazard for residents staying in its immediate vicinity (IISI & UNEP, 1997).

Particulate matter, consisting of organic and inorganic substances and originating from slag disposal- and reclamation practices, can affect the respiratory systems of humans when inhaled. Respiratory disease is caused when the fine particles are stuck deep into the lungs where it is trapped for long periods and causes inflammation in the lungs (IISI & UNEP, 1997). The presence of dust may also have an effect on vegetation and crops in the immediate vicinity of the slag dumps. Normal plant growth and yield may be reduced when ordinary plant functions, such as photosynthesis, are restricted by the deposition of fine slag dust particles on leaf surfaces which blocks the intercellular gas exchange (IISI & UNEP, 1997).

9.5 Aesthetic value

The presence of large and unsightly dumps and clouds of dust, generated by winds and on-site activities, are highly visible from roads and nearby residential areas and have a negative effect on the aesthetic value of an area (IISI & UNEP, 1997). An example of such a slag dump can be seen in figure 8.

Figure 8: An aerial photograph taken of a slag dump at the Iscor Vanderbijlpark works



10. INTEGRATED ENVIRONMENTAL MANAGEMENT

After having indicated the volumes of slag disposed off annually in South Africa and having discussed its impacts on the environment, it can be concluded that this activity should be appropriately managed in an attempt to avoid or limit the possible risks to the environment. The disposal of slag should therefore be controlled or managed in such a way as to completely avoid or minimise the already discussed impacts on water resources, air- and soil quality, the aesthetic quality of an area and the health and well being of all forms of life.

The driving force in trying to achieve this goal can be described as what is commonly known as the "carrot-and-stick" principle. Although good environmental practices can be encouraged through the use of fiscal measures, economic incentives and increasing profits, it remains a reality that environmental regulatory measures are still needed to effectively avoid the adverse environmental impacts associated with waste disposal, including the disposal of slag. These regulatory measures include environmental legislation, guideline and minimum requirements documents from Government Departments specifically dealing with the environment (e.g. DWAF) and serves as a handy tool to safeguard and enforce good slag disposal practices (Barnard, 1999).

The Constitution of the Republic of South Africa, the Environment Conservation Act and the National Environmental Management Act are examples of general framework legislation specifically aimed at securing the aims of environmental management and will therefore also serve as the basis of the management of slag disposal practices (Barnard, 1999).

10.1 The Constitution of the Republic of South Africa, Act 108 of 1996

10.1.1 Introduction

The Constitution Act is the supreme or highest law of the Republic of South Africa. It provides a general framework within which any law or conduct inconsistent with its provisions would be invalid while its obligations imposed must be fulfilled. The Bill of Rights forms part of this legislative framework and its aim is to "enshrine the rights of all people in our country and affirms the democratic values of human dignity, equality and freedom." (Section 7(1))(Barnard, 1999).

Sections 24, 32, 33, 36 and 38 are of particular relevance to Steel Industries as it creates the basis of the protection of a private person's environmental rights from possible infringement caused by a Steel Industry's slag disposal practices, but also secure a steel industry's need for development.

10.1.2 The main environmental right

Section 24 of the Bill of Rights contains the main, overarching environmental right and provides that everyone has the right –

(a) *to an environment that is not harmful to their health or well being; and*

(b) *to have the environment protected, for the benefit of present and future generations through reasonable legislative and other measures that –*

(i) prevent pollution and ecological degradation;

(ii) promote conservation; and

(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

Section 24(a) is worded in the negative, most probably to avoid putting a positive, but very stringent obligation upon the state to provide an environment which benefits and ensures the "health" and "well being" of people (Barnard, 1999; Loots, 1997). Although not specifically stated in this section, the intention is that certain actions or remedies, such as an interdict or a claim for damages, will provide the appropriate relieve where an adjacent landowner or resident's "health or well-being" is affected by the negative impacts caused by an industry's slag disposal practices on the surrounding environment (Loots, 1997).

Section 24(b) guarantees a person's right to have the environment protected "through reasonable legislative and other measures" in order to prevent pollution and ecological degradation (Barnard, 1999; Loots, 1997). The importance of this section lies in the fact that a person who is convinced of the fact that the presence of a slag dump is causing environmental pollution or ecological degradation may now approach a court for an order compelling state authorities to take positive and pro-active steps to protect the environment as they are now expressly authorised to do so by this section. The local community, which may include adjacent landowners, downstream water users and residents within the impact area of slag dumps, are therefore empowered to initiate steps to have their environment protected and do not have to rely solely on government for this purpose (Barnard, 1999).

10.1.3 Sections of the Constitution in support of the main environmental right embodied in section 24

Sections 32, 33,36 and 38 of the Constitution serve to enforce the main environmental rights embodied in section 24 of the Act.

Section 32 allows access to any information held by the state or any other person and which is required to exercise or protect any rights. The implication is that a person whose rights have been infringed by pollution originating from slag dumps, for example a landowner who suffered material damages because he irrigated his crops with contaminated water originating from slag dumps, can have free access to the technical information gathered through research projects, data gathering, assessments and reports to prove his case and protect his rights (Barnard, 1999; Loots, 1997).

Environmental regulatory legislation and policies are implemented and enforced mainly by administrative authorities entrusted with extensive decision making and enforcement power, but section 33 ensures that these extensive powers are exercised in a lawful, reasonable, fair and justifiable manner (Barnard, 1999; Baxter, 1991; Kidd, 1997; Loots, 1997; Southwood, 1998).The measurement of such lawfulness, reasonability, fairness and justifiability is inherently flawed, as its interpretation will still be subjective. The disposal of slag may, for example, only be conducted once a permit or an exemption is granted by the DWAF as explained later on in paragraph 10.4.6.2. This is a process of administrative decision-making and is administered by an official to whom wide and discretionary power is delegated to. A person whose rights or interests are affected by the granting of such a permit, for example permitting the creation of an unsightly slag dump in an area renowned for its natural aesthetic value, has the right to be furnished with the written reasons for the administrative decision taken. It follows that the decision should also be justifiable in relation to the reasons given (Barnard, 1999; Baxter, 1991 Kidd, 1997).

Section 36 allows for the limitation of any right entrenched by the Constitution, including the main environmental right, to the extent that such a limitation is reasonable and justifiable taking into account the nature of the right, the importance of the purpose of the limitation and the nature and extent of the limitation (Barnard, 1999; Kidd, 1997; Loots, 1997). The implications of this section on steel industries whose slag disposal practices have resulted in legal action in the form of an interdict or claim for damages being instituted against such an industry, is that the rights of the aggrieved party, applicant or claimant can reasonably and justifiably be limited. The steel industry's contribution towards foreign exchange earnings, job creation and other economic or social benefits, would justify such a limitation of rights.

The concept of class action is introduced to our law by section 38, allowing one person to bring an action on behalf of or in the interest of a group of persons whose environmental rights have been infringed by a steel industry's slag dumping practices (Barnard, 1999). An example would be the case where a local resident represents the community in bringing a court order ordering a steel industry to control the dust emanating from its slag dumps as it causes a nuisance to residents and infringes their rights to a pollution free environment.

10.2 *The relationship between the Environment Conservation Act 73 of 1989 and the National Environmental Management Act 107 of 1998 concerning environmental management*

Certain aspects of the environment and its management is currently jointly regulated by the Environment Conservation Act 73 of 1989 (ECA) and the National Environmental Management Act 107 of 1998 (NEMA). Before the enactment of the NEMA in January 1999, the ECA was regarded as the single most important environmental statute with its primary purpose to create a foundation for an environmental and resource management system and to co-ordinate all actions affecting the environment (Barnard, 1999). The main purpose of NEMA is to establish a general legislative system to manage the environment, co-ordinate environmental governance in South Africa and to provide a principle based legal framework to create sectoral laws which regulate specific environmental issues such as waste disposal or water resource management (Barnard, 1999).

One such an example is pollution control and waste management, which is presently, covered by sections 19 and 20 of the Environment Conservation Act. These sections will be repealed later on by the enactment of sectoral legislation specifically dealing with waste disposal and transforming its management into a more streamlined and outcome based approach. The application of sections 19 and 20 of the Environment Conservation Act on the disposal of slag will later, under the discussion of the act, be further elaborated on.

10.3 *National Environmental Management Act 107 of 1998*

10.3.1 The objective of the Act

The Act is mainly aimed at providing for co-operative environmental governance between state departments concerned with environmental functions (e.g. the Department of Water Affairs & Forestry (DWAF) and the Department of Environmental Affairs and Tourism). It also provides a legal framework to give effect to the constitutional rights relating to the environment and covered in section 24 of the Constitution.

10.3.2 National Environmental Management Principles and its application

The National Environmental Management principles, which underscribes concepts such as sustainable development and the duty of care, are set out in section 2 of the act and serves as a framework to develop and facilitate environmental management. The principles specifically relevant to the Steel Industry and the management of slag disposal includes the following:

- **The principle of sustainable development**

This principle provides that people and their needs should receive priority during the implementation of environmental management, always recognising their physical, psychological, developmental and cultural interests. The factors needing to be considered by a Steel Industry for their slag disposal and dumping actions to be sustainable, include the following actions which should be altogether avoided, minimised and remedied:

- The disturbance of ecosystems and loss of biological diversity
- The disturbance of landscapes
- Waste generation
- The development, use and exploitation of renewable resources and the ecosystems of which they are a part
- Not applying a risk-averse and cautious approach, and not taking into account the limits of current knowledge about the consequences of decisions and actions
- Pollution and degradation of the environment

Over and above the requirement of environmental sustainability, the reference to sustainable development also specifically calls for the activities of an industry to be socially and economically sustainable, thus referring to the fact that a balance must be struck between the social, environmental and economic factors. Although the steel industry's slag disposal practices might constitute such identified unsustainable environmental practice, its contribution towards social and economic development cannot altogether be ignored as it weighs heavily in favour of the industry. A steel industry's main economic activity, which is the production and delivering of steel products, generates valuable foreign exchange through the export of its products and benefiting the South African economy on a larger scale. On a more local level the steel production process requires a substantial input of manpower and creates employment opportunities for workers on a unskilled, semi-skilled and skilled level, thereby making a valuable contribution towards the social upliftment in the area.

It can therefore be concluded that although the disposal of slag may not always be regarded as an environmental sustainable activity, the overall activities of a steel industry contributes towards social and economic sustainability and recognizes people's physical, psychological, developmental and cultural interests.

- **Duty of care and remediation of environmental damage**

The principles of a duty of care and remediation of environmental damage caused by environmental pollution set out a general framework and parameters within which pollution control and remediation measures can be taken. Section 19 of the National Water Act 36 of

1998, which deals with the prevention and remediation of water pollution, has religiously followed this framework. As discussed earlier under 9.3, the potential of surface and groundwater pollution resulting from slag disposal practices resembles the most significant negative impact on the environment. The use of this contaminated water for domestic-, agricultural and industrial purposes and the maintenance of aquatic life has significant impacts on the health and will being of human-, plant- and animal life as well as on products. The principles of a duty of care and the remediation of environmental damage is therefore covered at length in the discussion of section 19 of the National Water Act.

- **The principle of environmental justice**

Before the start of the era of environmental consciousness in the 1970's, it was practice for large industries, including steel industries, to develop their production plants, conduct their operations and dispose of their waste in areas inhabited by members of lower income groups or political unpowered race groups, taking unfair advantage of their lack of economic or political power to speak up against industrial giants.

The principle of environmental justice refers to the fact that slag should not be deliberately disposed of in areas inhabited by particularly vulnerable and disadvantaged persons in order to benefit from their inability to resist such action by taking legal action against a steel industry.

- **Private prosecution**

In broad terms this principle provides relief in the form of a private criminal prosecution as it enables any person, acting in the public interest or in the interest of protecting the environment, to institute private prosecution where an obligation in terms of environmental law is being breached and such breach creates an offence. In cases where the industry is in breach of an environmental obligation, for example an obligation not to allow contaminated run-off from slag dumps to pollute the soils and surface water of adjacent landowners, an affected or interested party may utilise the option of a private prosecution against such an industry.

- **Environmental health and safety**

The responsibility for the environmental health and safety consequences of a product, process, or activity is placed on its creator or producer throughout its entire lifecycle. It therefore follows that the steel industry maintains its liability for the impacts or damage caused to the environment, human health and property throughout the lifecycle of its products, by-products and waste products. It serves as confirmation of the fact that the industry will retain its legal liability for environmental damages caused by the slag produced, even when finally discarded in the form of slag dumps.

10.4 Integrated waste management

The purpose of integrated waste management is to plan the management of waste in advance, by relying on facts relating to its nature, composition and quantity in order to "curtail the risks associated with the handling and disposal of waste to the point where they are acceptable to man and the environment" (DWAF, 1998, p v). Waste is defined in the definitions and the regulations made under the Environment Conservation Act as "any matter (whether gaseous, liquid or solid or any combination thereof), which is from time to time designated by the Minister by notice in the Gazette as an undesirable or superfluous by product, emission, residue or remainder of any process or activity". Although slag is not as such designated as a "waste", it can, for the reasons discussed under 10.4.6.1, still be regarded as a form of waste as contemplated by the Minister.

The process of waste management, compared in figure 9 with an upside down pyramid, involves the reduction of waste volumes through its prevention, minimisation, recovery, treatment and the eventual disposal according to environmentally safe and acceptable practices (DWAF, 1998; Miller, 1996). Government, acting through the Department of Water Affairs and Forrestry, attempts to achieve the latter goal through the implementation of section 20 of the Environment Conservation Act and the Waste Management series, which will be elaborated on later.

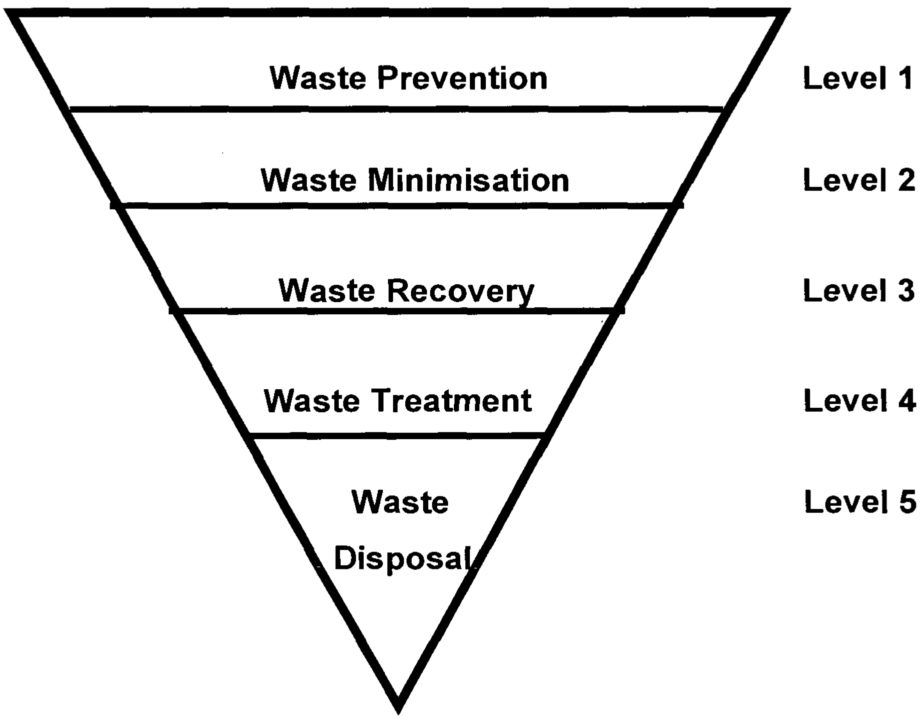


Figure 9: The process of Integral Waste Management (DWAF, 1998; Miller, 1996)

10.4.1 Level 1: Waste prevention

Waste prevention refers to the prevention and avoidance of the production of solid and hazardous wastes or hazardous substances by changing industrial processes to eliminate the use of material, which contains harmful substances (DWAF, 1998; Miller, 1996). This is not a viable option as far as the formation of slag is concerned, as no alternative input of material has as yet been identified to replace the raw material input during the steel manufacturing process (Nolte, 2000; Personal communication).

10.4.2 Level 2: Waste minimisation

Industrial processes inevitably generate certain amounts of residue, but for economic and environmental reasons it would be better to minimise residues through the application of processes optimisation or cleaner technology (DWAF, 1998). In the South African context the steel manufacturing process is already optimised to minimise the quantities of slag produced by the use of the best raw material obtainable from South African mines (Nolte; 2000; personal communication).

10.4.3 Level 3: Waste recovery

Because of the economic viability of waste recovery the steel industry re-uses a large portion of its by-products, which include slag, arising from the steel making process. The re-use options of slag would range from building and road construction, the manufacture of cement, concrete aggregates, glass manufacture and as a mineral supplement and liming agent in agricultural soils (IISI & UNEP, 1997).

The chemical and physical characteristics of slag may, however, have a hampering effect on its re-use options. A decline in phosphorous ores means that less slag can be used as fertiliser for soils. According to the IISI (1997) less slags are now used for road building and pavements because of the problems associated with expansion and cracking (IISI & UNEP, 1997).

10.4.4 Level 4: Waste treatment

It is important to determine the properties of waste, its risk to human health and the environment and the significance of such risks before waste can be effectively managed. Waste treatment is one option of managing waste and includes physical treatment, chemical treatment, immobilisation, solidification, encapsulation and incineration. In the South African context slag cannot be chemically treated to reduce its hazardousness, because of the large volumes of slag disposed of. The slag product is, however, physically treated by spreading it over a larger surface area in an attempt to reduce its concentrations of hazardous chemical components and its impacts on the environment (Fourie; 1999; Nolte; 2000; personal communications).

10.4.5 Classification of wastes

The treatment as well as the disposal of any waste, including the by-product slag, depends on its classification. For this purpose the DWAF developed a waste classification system, distinguishing between general and hazardous waste, which classifies waste according to waste type, size of the operation and the potential for significant leach ate generation (DWAF, 1998; Stein, 1997). Waste can either be classified as general waste, not posing a significant threat to public health or the environment, or as hazardous waste because of its toxic, chemical or physical properties (DWAF, 1998). Blast furnace slag can generally be classified as general waste, while slag originating from the Basic Oxygen Furnace and Electric Arc Furnace processes contains hazardous components introduced via scrap metal and is generally classifies as hazardous waste (Nolte, 2000; Personal Communication). The dangers posed by slag identified as hazardous lies in the detrimental, acute or chronic impacts on human health and the environment and requires stringent technical control to avoid such harm from being caused (DWAF, 1998).

The steps identified by the DWAF and indicated below in figure 10 can be used as guideline to establish if a slag waste body can be classified as hazardous or not (DWAF, 1998).

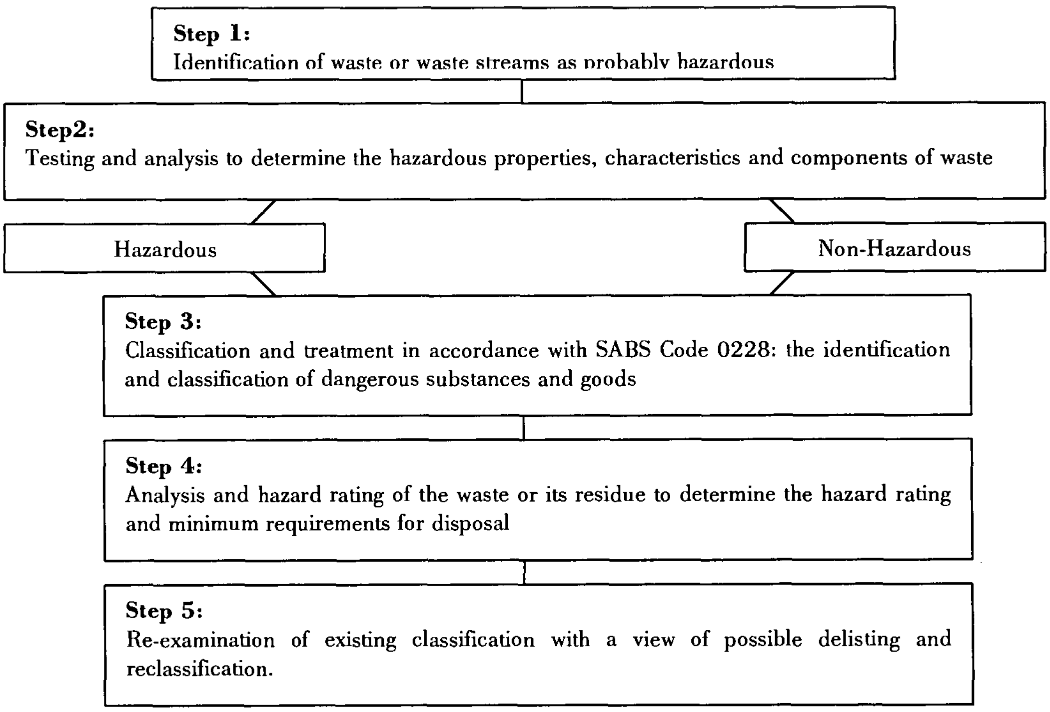


Figure 10: Classification of hazardous waste (DWAF, 1998)

When it is suspected that slag can possibly be hazardous (step 1), the slag should be tested and analysed to establish its properties, components and substances (step 2). In general wastes emanating from industries like the medical, agricultural, textile and metal industries, which include steel industries, can be expected to be hazardous (step 1). The results of such an analysis are then compared with the properties and substances listed in the SABS code 0228 (step 3), the Basel Convention and the waste classification tables appearing in the Minimum Requirements for Hazardous Waste Disposal and if it conforms the slag is likely to be hazardous (DWAF, 1998). Slag contains certain chemical substances, which can be classified as corrosive or toxic according to the SABS 0228 classification system, pointing to the possibility that slag can be hazardous. Tests are then conducted on the slag (e.g. acid rain test) and the results are subsequently compared with the values indicated in the Hazardous waste Classification tables. If a substance (e.g. lead) in a slag waste body exceeds the Acceptable Environmental Risk or the values allowed for disposal as indicated in these classification tables, the entire slag waste body will be classified as hazardous. The volume of slag disposed of in an area, and therefore the load of the identified chemical substances carried within, will determine its hazardousness.

The main aim of establishing the hazardous rating of a slag waste body is to identify and determine the relevant Minimum Requirements for its disposal. Slag is classified according to the risk posed by its hazardous components and its rating will then determine the class or type of hazardous waste landfill to be constructed (DWAF, 1998).

Table 5: The rating of hazardous waste
(DWAF, 1998)

Hazard Rating 1	Extreme Hazard	Contains significant concentrations of extremely toxic substances, including carcinogens, teratogens and infections wastes.
Hazard Rating 2	High Hazard	Waste with highly toxic characteristics or extremely toxic substances, which are not persistent, including certain carcinogens.
Hazard Rating 3	Moderate Hazard	Moderately toxic waste containing substances potentially highly harmful to human health and the environment, but not persistent.
Hazard Rating 4	Low Hazard	Concentrations of potentially harmful substances pose a limited threat to human health or the environment.
Hazard Rating Lower than Rating 4		Hazard low enough for waste to be disposed of at a General Waste landfill.

10.4.6 Level 5: Waste disposal

It is a reality that, as far as waste is concerned, there is "no away in to throw away" (Miller, 1996, p556), which means that no matter how well the various levels of waste management is applied, a percentage of waste will still have to be disposed of in the environment (Miller, 1996).

Improper slag disposal practices may have possible significant impacts on the health of people and the environment, especially on water resources and water quality, which explains why it is necessary to manage the disposal of slag through a legislative framework. The DWAF acts as the responsible authority as far as the control of waste disposal is concerned mainly due to the risk of water pollution associated with the disposal of waste (DWAF, 1998). It is for this reason that the DWAF also acts as the regulative authority as far as the disposal of slag is concerned. The central principle underlying the legislative regulation of slag disposal is that slag, like all other waste, must be disposed of at a site where adequate measures are taken to protect against further environmental degradation, surface and groundwater pollution (DWAF, 1998). The DWAF utilises its discretionary powers to establish the nature and extent of such adequate measures, but has developed a set of guide ling documents, the so-called Waste Management series, to provide guidance on the adequate measures to be taken. Section 20 of the Environment Conservation Act specifically deals with the disposal of waste, which includes the disposal of the by-product slag. The relevance of this section as far as the disposal of slag is concerned, and its provisions will subsequently be discussed.

- **The applicability of section 20 of the Environment Conservation Act 73 of 1989 to slag as a form of waste**

The Minister, in the Government Notice 1986 of 24 August 1990, designated a number of "wastes" to be regulated under section 20 of the Environment Conservation Act, but also excluded certain wastes as these were already regulated by other acts, e.g. the Mines and Works Act 27 of 1956 (Stein, 1997). The disposal of any minerals, tailings, waste-rock or slimes produced by or resulting from the activities of a mine or works were excluded from section 20, because of its regulation through the Mines and Works Act 27 of 1956. The Steel Industry was, at the time when the Mines and Works Act were still in place, defined as a "works" in terms of this act and therefore excluded the regulation of slag disposal under section 20 (Barnard, 1999). The question that arises is if a Steel Industry and its slag disposal practices will now be excluded from section 20 of the Environment Conservation Act, as the Mines and Works Act have now been repealed and the disposal of slag is not explicitly regulated by any act (Barnard, 1999).

At the time of the promulgation of ECA, Steel Industries were governed by the Mines and Works Act and its slag disposal practices were therefore regulated in terms of the Regulations to the Mines and Works Act. There was therefore no need to regulate slag disposal practices under section 20 of the Environment Conservation Act. The Minerals Act 50 of 1991, however substituted and repealed the Mines and Works Act, leaving the disposal of slag unregulated as this act does not pertain to "works" which include steel industries (Barnard, 1999).

The true intention of the legislature should therefore be established. The intention of Government Notice 1986 was to exclude the steel industries slag disposal practices from the provisions of section 20 of the Environment Conservation Act, solely because its disposal activities were, at that time, already governed by the Mines and Works Act. When the disposal of slag by a Steel Industry was excluded from the new definition in the Minerals Act, the reason for its exclusion from section 20 of the Environment Conservation Act fell away and it can hardly be argued that the intention of the legislature was to exclude them from any environmental control. It can therefore be concluded that all waste produced and disposed by the manufacturing components of the Steel Industry, which include slag, falls within the definition of "waste" and are regulated as such by section 20 of the ECA as discussed below (Barnard, 1999).

- **Section 20: Waste management**

Section 20 of the Environment Conservation Act specifically regulates waste management and states that, "no person shall establish, provide or operate any disposal site without a permit issued by the Minister of Water Affairs." It therefore follows that slag may not by disposed of on any disposal site without having been permitted to do so by the DWAF. The Minister, acting through his delegates, is authorised to issue such a permit subject to certain conditions, for example the construction of interception measures around slag dumps, and may alter or cancel the permit or exempt any person from obtaining a permit (section 20). The DWAF has the power to cancel or revoke a section 20 permit when it is convinced that an industry did not adhere to the permit requirements or the conditions to the permit. The minister can require from the permit applicant to submit technical and other information (e.g. an Environmental Impact Assessment indicating the nature and extent of the environmental impact) enabling him to make a decision on a permit application (DWAF, 1998). Once convinced that slag was correctly classified according to the procedures prescribed in the Minimum Requirements Documents and that the correct technical standards were applied during the construction of the slag disposal site, the Minister or his delegates will decide whether or not such a permit should be granted (DWAF, 1998). In terms of section 20(5) the DWAF can also issue directives to control and manage the slag disposal site, and prescribe how the slag disposal site may be utilised or closed.

In terms of the legislation the DWAF is entrusted with discretionary powers as far as the issuing of permits and the conditions thereto are concerned. Within the framework of this enabling legislation the DWAF developed a management structure by introducing a waste management series, the so-called minimum requirement documents, also providing the basic framework within which the discretionary powers are exercised (DWAF, 1998).

- **The Department of Water Affairs Waste Management series**

(i) Introduction

The Department of Water Affair's waste management series consists of three documents, namely the Minimum Requirements for Waste Disposal by Landfill, Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste and the Minimum Requirements for Water Monitoring at Waste Management Facilities (DWAF, 1998).

The introduction of the Waste Management series is aimed at providing a reference framework of standards for waste management in South Africa, to ensure that the same environmental standards and objectives are applied throughout the country, to improve the overall standard of waste disposal and to take pro-active steps to prevent the degradation of water quality and the environment as a whole (DWAF, 1998). The contents of these documents is of particular importance to a Steel Industry's disposal of slag, as the regulatory standards, the classification system for various types of wastes and the subsequent identification of the appropriate waste disposal site is enforced through the landfill permitting system as provided for in section 20(1) of the Environment Conservation Act. It therefore follows that different technical standards will apply to the construction of a landfill for the purpose of disposing slag classified as either general or hazardous waste (DWAF, 1998). The DWAF will only grant a section 20 permit to allow the disposal of slag into the environment once it is convinced that the requirements set out in the Minimum Requirements Documents are being met.

(ii) Contents of the Minimum Requirements documents

These documents set out the procedures and actions to be followed and information that is required from the permit applicant when an application is made for a waste disposal permit in the case of a new or operating waste disposal site or to close an existing waste disposal site (DWAF, 1998).

The hazard rating of a slag waste body determines the class of landfill that should be used. It is already mentioned that slag produced by the blast furnace is normally classified as general waste, thereby qualifying for disposal at a general waste landfill. Basic Oxygen Furnace and Electric Arc Furnace slag, normally obtaining a hazardous rating of 3 or 4, may only be disposed of at a H:h landfill (Nolte, 2000; Fourie, 2000; Personal Communication). This classification system determines the technical aspects and procedures for landfill site selection, design, operation, closure and monitoring of a landfill and the involvement of interested and affected parties during this process (DWAF, 1998).

When a new slag disposal site is selected, the selection process is determined by the technical suitability and public acceptance of possible and alternative slag disposal sites. During this process sites with inherent flaws will be eliminated and alternative sites will be considered. The presence of an aquifer and the possibility of its contamination through the migration of polluted seepage water from slag dumps, will make such a site unsuitable due to its significant risk to the environment or human health. The suitability of a slag disposal site will have to be determined through a site investigation process, which includes technical investigations, environmental impact assessments and consultations with interested and affected parties (DWAF, 1998). The design and the location of the site will then be based on the information gathered.

A new slag disposal site can only be developed and commissioned and an existing site upgraded or rehabilitated once a permit is granted by the Department of Water Affairs and Forestry. The DWAF will only grant a section 20 permit once it is satisfied that slag was correctly classified as either general or hazardous waste, an environmental impact assessment confirmed the feasibility of the site and the correct technical standards were applied for the design and construction of a landfill. Only after the Department has approved the completed construction can its operation begin (DWAF, 1998). The DWAF should be informed of the closure of a slag disposal site at least one year before the intended closure in order to determine its end-use and closure requirements. Monitoring of the closed slag disposal site for leaking of leach ate must continue for at least 30 years after its closure, as the permit holder will be "primarily and ultimately accountable for the landfill and any effect it may have on the receiving environment." (DWAF, 1998, p. v).

It follows that slags should be toxicologically tested and analysed to determine their classification as either general- or hazardous waste (Fourie, 1999; Personal communication). A subsequent hazardous ranking will be indicative of the type of landfill to be constructed in order to obtain the required permit for slag disposal. To the steel industry site selection is of significant importance as it will result in the acceptability of slag disposal practices to the local community, the general public and the environment, but will also enable the cost effective design and operation of the waste disposal site.

- **The powers of the Minister or his delegates where the environment is damaged, endangered or detrimentally affected.**

In circumstances where "any person performs any activity or fails to perform any activity as a result of which the environment is or may by seriously damaged, endangered or detrimentally affected," the Minister, competent authority, local authority or government institution is in terms of section 31A(1) authorized to direct such a person, in writing, to cease such an activity or to take the necessary steps that are deemed fit.

It follows that where a steel industry's activities, which include the disposal of slag in an uncontrolled manner, pollutes the environment to cause serious damage or ecological degradation, the industry is running a risk to be ordered by the Minister to cease such an activity or to start clean-up or rehabilitation actions as the Department deems fit. Should the industry fail to apply the direction given, the Minister or delegated authority may perform the required actions or steps themselves and subsequently recover the costs from the industry liable for such pollution or environmental damage (section 31A(3))

- **Criminal offences and penalties**

Where an industry is continuing its slag disposal practices without the necessary permit having been issued, or fails to comply with a condition of a permit, permission, authorization or direction given the directors "shall be guilty of an offence and liable on conviction to a fine not exceeding R 100 000 or to imprisonment for a period not exceeding 10 years or both" (section 29(4)).

10.5 Water quality management

10.5.1 Introduction

The Department of Water Affairs and Forestry, acting as custodian of the country's water resources, is responsible for maintaining the fitness of these water resources for a specific use, but at the same time achieve a balance between the use and protection of our water resources. According to Dr Henk van Vliet, Chief Director at the DWAF, the aim is not to prevent all impacts on water resources, as this will not allow the country to achieve social and economic growth, but a balance should be obtained between the use and protection of water resources to ensure that there will be water for everyone (equity) and for ever (sustainability) (DWAF, 1998). This statement also holds truth as far as the disposal of slag is concerned, as this practice will inevitably impact on the surrounding water resources as already pointed out. The ultimate goal will however still be to manage these associated impacts in such a way that the water body will retain its integrity and quality for use in the future. The DWAF aims to achieve this goal through the implementation and administration of the Water Quality Guidelines and the National Water Act 36 of 1998.

10.5.2 The Department of Water Affairs and Forestry's Water Quality Standards for South Africa.

The DWAF has set down a set of standards, the Water Quality Standards, to provide the necessary information base and guidelines to maintain the quality of water and its fitness for a specific use, which includes domestic-, agricultural-, industrial- and recreational use and the maintenance of a healthy aquatic environment (DWAF, 1996). The quality of water specifically refers to its physical, chemical, biological and aesthetic properties, which determines its fitness for use. These properties are determined and influenced by the constituents of water, which, *inter alia*, include temperature, colour and the presence of chemical substances (e.g. iron, lead or calcium) suspended or dissolved in water. In order to determine its fitness for use a judgement will have to be made on the desirability or acceptability of water with a specific use in mind by considering the available scientific and technical information for each and every water quality constituent. Water can subsequently be classified as ideal, acceptable, tolerable, unacceptable or completely unfit for use.

It is already mentioned that leach ate derived from slag dumps usually contains, *inter alia*, the chemical substances aluminium, fluorspar, iron, lead, magnesium, nickel, selenium and sulphur. For each of these chemical substances normally associated with the disposal of slag the DWAF has set down a Target Water Quality Range, already set out under paragraph 9.2. These values reflect the ideal range of chemical concentrations in water to be strived for to maintain the good quality of a water body and its fitness for use (DWAF, 1996).

10.5.3 The National Water Act 36 of 1998

The aim of the Act is to protect the country's water resources by taking into account the basic human needs of present and future generations, the protection of aquatic ecosystems and their biological diversities and by reducing and preventing the pollution and degradation of water resources. Water pollution, as previously discussed at length, is the main and most significant impact associated with the disposal of the by-product slag on dumps. Because of its potential to impair the quality of surface- and groundwater resources and render it unfit for use, section 19 of the Act, which specifically deals with water pollution and its remediation, is of particular concern to a steel industry.

- **Pollution prevention**

(i) Definitions of "pollution"

Pollution is defined in the definitions to the act and means "the direct or indirect alteration of the physical, chemical or biological properties of a water resource so as to make it –

(a) less fit for any beneficial purpose for which it may reasonably be expected to be used; or

(b) harmful or potentially harmful –

    (c) to the welfare, health or safety of human beings;

    (d) to any aquatic or non-aquatic organisms;

    (e) to the resource quality; or

(f) to property."

From the earlier discussion on the impacts of the slag dumps on the surface- and groundwater sources it is clear that a steel industry's slag disposal practices may cause pollution to water sources by directly and indirectly altering the physical and chemical make-up of a water resource, making such a water resource less fit for its intended use and potentially harmful to humans, aquatic and non-aquatic biota and property. It therefore follows that the provisions of section 19 with regard to pollution prevention will be applicable as far as the dumping of slag on the premises of a steel industry is concerned.

(ii) Obligation to remedy the effects of pollution

Section 19 contains the provisions for the prevention and remediation of the effects of pollution, and is extended to allow wider liability for pollution control measures than its predecessor, the Water Act 54 of 1956.

Section 19 applies to the owner of land, a person in control of land or a person who has the right to use the land on which any activity or process is or was performed, or any other situation exists which causes, has caused, or is likely to cause pollution of a water resource or coastal marine water. This section puts an obligation on these persons to take all reasonable measures to prevent such pollution from occurring, continuing or recurring (Section 19(1)).

The measures referred to may include the following actions as specified in Section 19(2):

- to leave, modify, or control any act or process causing pollution;
- to comply with a prescribed waste standard or management practice;
- to contain or prevent the movement of pollutants;

- to eliminate any source of pollution;
- to remedy the effects of the pollution; and
- to remedy the effects of any disturbance to the bed and banks of a water course.

A steel industry causing pollution to the environment by allowing contaminated run-off and leach ate originating from slag dumps to pollute ground- and surface water sources falls within the identified category of persons and incurs an obligation to prevent such pollution by applying the measures prescribed by the Act.

(iii) Interpretation of "reasonable measures"

At this point, and as no clear definition is given of "reasonable measures" in the Act itself, it is necessary to elaborate more on the issue of exactly what actions will have to be taken by a steel industry to constitute such reasonable measures. In the absence of case law specifically pertaining to this terminology as contained in section 19(1), the general meaning of the word "reasonable" as used in the South African law should be applied. The criteria of the "reasonable man" will therefore apply and points to the "reasonable measures" taken by a "reasonable man" acting under the same circumstances and scenario of facts.

Throughout the literature and through the cases, various considerations were identified in the South African law as guidelines or measures to ascertain whether any steps would have been taken by a "reasonable man" and what the extent of such steps should be. The issue was addressed by the Appellate Division in the case of *Pretoria City Council v de Jager 1997 (2) SA 46(A)* and four such considerations or measures were identified as having an influence on the reaction of the "reasonable man" in a situation involving foreseeable harm to others, namely:

(i) the degree or extent of the risk created by the actor's conduct;
(ii) the gravity of the possible consequence if the risk of harm materialises;
(iii) the utility of the actor's conduct; and
(iv) the burden of eliminating the risk of harm.

In general, the inquiry whether the "reasonable steel industry" would have taken measures to prevent foreseeable degradation to the environment or harm to the public and resulting specifically from the industry's slag disposal practices, involves a balancing of these four considerations. Whether in a particular situation the steps actually taken by an industry to guard against foreseeable harm to the environment and the public are to be regarded as reasonable or not, depends on an evaluation and assessment of all the facts and circumstances of the specific situation. A reasonable industry would foresee that harm or potential harm could be caused to the health and safety of human beings, aquatic and non-aquatic organisms, resource quality and property by allowing polluted run-off and seepage water from the slag dumps to reach surface and groundwater resources. The construction of leach ate- or seepage dams and ditches around slag dumps would constitute such reasonable steps to prevent such foreseeable harm from materialising.

(iv) Directives to take reasonable measures

When a steel industry fails to apply the "reasonable measures" as required under section 19(1), the Catchment Management Agency (CMA) or the Department of Water Affairs (DWAF) may, in terms of section 19(3), direct the defaulting party to:

- commence taking specific measures before a given date;
- diligently continue with these measures; and
- complete them before a given date.

It is important to note that the directives given to a defaulting steel industry must also be "reasonable". In the event where a liable industry fails to comply with the directives given or comply inadequately (for example to construct seepage- and run-off collection dams at strategic locations around slag dumps), the CMA or DWAF may take the necessary steps to remedy the situation themselves (section 19(4)) and recover the costs thereof from the liable person or persons (section 19(5)). Where an industry is given a fair warning and/or deadline to comply which the given directives, the DWAF/CMA may only act on their own initiative and take the necessary clean-up action where the industry fails to comply with such directives. The DWAF can, for example, take the necessary steps to rehabilitate soil where its quality has been affected by the overflow of polluted water from the collection dams and recover the costs incurred from the defaulting steel industry.

(v) Recovery of costs

The CMA or DWAF may, in terms of the discretionary power provided by section 19(5) and in order to rectify a situation or activity which causes, has caused or is likely to cause pollution of a water resource, recover all costs reasonably incurred and which may include labour, administrative and overhead costs, "jointly and severally" from the following persons:

- the person who is or was responsible for, or who directly or indirectly contributed to the pollution or potential pollution;
- the owner of the land at the time when the pollution or the potential for pollution occurred or that owners successor in title any person;
- the person in control of the land or any person who has the right to use the land at the time when the activity or process is or was performed or undertaken or when the situation came about;

- any person who negligently failed to prevent the activity or the process from being performed or undertaken; or the situation from coming about.

This section now gives legal status to the "polluter pays" principle, pointing to the fact that costs incurred as a result of clean-up measures taken by the DWAF or CMA may be claimed from a steel industry whose slag disposal practices caused the pollution. The status quo is that clean-up and remediation costs may be claimed from the steel industry even if the pollution originating from slag dumps occurred in the past and irrespective of the fact that the industry may have been in compliance with statutory requirements at the time.

In terms of section 19(5) the CMA or DWAF is given a discretion as from whom and to what extent the recovery of costs will be made. All potentially liable parties should be granted the right to be heard and the authorities must exercise the given discretionary powers reasonably. The meaning of the words "jointly and severally" in section 19(5) point to the fact that costs may be recovered from any liable person in full or in part. Should more than one person be liable in terms of the above section, the CMA or DWAF must, at the request of any of those persons and after giving them an opportunity to be heard, apportion the liability, although such an apportionment does not relieve any of the parties involved of their joint and several liability for the full amount of the costs. It follows that the DWAF may still recover all costs incurred in terms of section 19(4) from any one of the parties to which the costs are apportioned to, leaving such a party with the option to recover their damages from the other liable third parties, but only after such payment was made to the DWAF.

In terms of section 19(6) the CMA or DWAF may recover costs "from any other person who, in the opinion of the Catchment Management Agency, benefited from the measures undertaken under sub-section 4, to the extent of such benefit". The measures undertaken being referred to are those taken by the DWAF and considered necessary to remedy a polluted and ecologically degraded environment. It follows that the industries downstream from a polluting property and various farmers making use of river water downstream, can be identified as parties who would benefit from such clean-up and remediation measures and could be held liable for the costs incurred by the DWAF under section 19(4) to the extent of such benefit.

If the disposal of slag on discard dumps resulted in the pollution of surface- and groundwater sources caused by contaminated run-off or leach ate originating from the dumps, the DWAF/CMA may, after having taken the clean-up or remediation measures themselves, recover the costs incurred from the steel industry. The steel industry will be liable for such costs under the circumstances identified. Should any other industry or party contribute towards the pollution causing the steel industry to share its liability, the DWAF may apportion the costs according to each party's contribution. The DWAF may, however, still recover the full costs from any one of the parties, leaving the other with a right of recourse against the other parties and after the costs have been paid.

10.5.3.1 Criminal offences and penalties

Numerous new offences have been created by the inception of the National Water Act and specifically relevant as far as a Steel Industry's slag disposal practices are concerned, section 151(1) indicates that no person or industry may:

- Fail to provide access to any books, accounts, documents or assets when required to do so under the Act;
- Fail to comply with permit conditions;
- Fail to comply with directives issued under section 19, which deals with the prevention and remediation of the effects of pollution
- Fail or refuse to give data or information required under the Act;
- Refuse to perform a duty or obstruct other persons from exercising their powers in terms of the Act;
- Unlawful and intentionally or negligently committing acts or omissions which pollutes or are likely to pollute a water resource or detrimentally affects or is likely to affect a water resource.

The directors of an industry convicted of such a transgression in terms of section 151(1) will be guilty of an offence and liable, on the first conviction, to a fine or imprisonment for a period not exceeding five years, or to both a fine and such imprisonment and in the case of a second or subsequent conviction, to a fine or imprisonment for a period not exceeding ten years or to both a fine and such imprisonment (section 151(2)).

Section 152 further enables the court to make an inquiry to establish the harm, loss or damages suffered by third parties as a result of the environmental pollution caused by the steel industry, and award compensation for such damages in favour of an affected person (section 153).

Offences relating to employer and employee relationships are covered by section 154 of the Act, and this section therefore gives statutory status to the common law principle of vicarious liability. Should an act or an omission by an employee or agent of the steel industry constitute an offence in terms of the Act and takes place with the express or implied permission of the employer, such an employer, together with the employee or agent, will be liable to conviction for that offence.

10.6 Air quality management

10.6.1 The Atmospheric Pollution Prevention Act 45 of 1965

10.6.1.1 Introduction

Air pollution in the form of dust generation is regulated through the Atmospheric Pollution Prevention Act and administered by the Department of Environmental Affairs and Tourism.

10.6.1.2 Sections 27, 28 and 29: Dust control

Sections 27, 28 and 29 specifically deal with dust control. The Minister may, by notice in the Gazette, declare an area to be a dust control area or include or exclude an area from a dust control area (section 27).

Any person who carries on an industrial process which causes a nuisance to local residents or has at any time deposited or permitted to deposit any matter on land within such a declared dust control area, and such matter exceeds 20 000 cubic meters in volume which in the opinion of the Chief Officer causes or is liable to cause a dust nuisance, is in terms of section 28 obliged to take the prescribed steps or adopt the best practicable means to ensure that such dust does not cause a nuisance. In the event of dust giving rise to a nuisance, the Chief Office can, in terms of section 29, regulate the nuisance by means of an abatement notice. This abatement notice may prescribe steps to be taken by the steel industry on which premises the dust is emanating or may require the industry to implement the best practical means to stop the nuisance. The best practical means are described in the definitions to the Act and points to measures which are technically feasible and economically possible, bearing in mind the well being of people. As this concept is flexible, its interpretation will depend on the circumstances of the case.

A steel industry should therefore establish if a slag disposal area falls within the boundaries of such a dust control area as this will mean that the steps prescribed by the Chief Officer or the best practical means option will have to be followed. Even if this is not the case, the industry should still be mindful that dust emanating from slag dumps may create a nuisance to local residents who may turn to there common law remedies, for example to apply for a prohibiting interdict, to resolve the situation.

10.7 Criminal offences and penalties

If the industrial slag disposal practices cause a nuisance and the industry fails to comply with the abatement notice or fails to apply the best practical means option, the industry will be guilty of an offence (section 29(4)). If convicted, the directors of the industry shall, in terms of section 46, be liable to a fine not exceeding R500 or imprisonment for a period not exceeding 6 months. In the case of a second or subsequent conviction, such a person will be liable to a fine not exceeding R2 000 or imprisonment for a period not exceeding one year.

11. COMMON LAW LIABILITY

11.1 Introduction

Environmental legislation, serving as useful tools to achieve the objectives of environmental management is, in general, poorly enforced by the South African regulatory authorities (Barnard, 1999; Kidd, 1997; Loots, 1997). The common law remedies, such as delictual claims for damages in terms of the Aquilian action and interdicts, are therefore useful instruments in the hands of private individuals or groups in cases where environmental disputes arise (Kidd, 1997). The common law remedies are discussed below.

11.2 The Aquilian or delictual action

The Aquilian action, also known as a delictual action, can be used by an aggrieved party to claim compensation in the form of damages if such damages suffered resulted from the wrongful act by a wrongdoer (Potgieter & Visser, 1993). In order to succeed with such a claim for damages to property or health caused by a Steel Industry's slag disposal practices, the following elements of a delict must by proved by the claimant:

11.2.1 A wrongful act or an omission

A wrongful act can manifest itself in various ways which includes an infringement of rights, which can either be a common law right or a right in terms of the Bill of Rights in the Constitution, the breach of a specific statutory duty or a breach of a duty to care. An omission to act in a positive way to prevent a damage causing situation under a person's control from materialising, also constitutes a wrongful act if there is a legal expectation that such a person would act in a positive way (Potgieter & Visser, 1993; Neetling *et al*, 1992). An example would be where a steel industry does not take positive, precautionary steps to avoid polluted runoff from entering and causing damage to another person's property.

When polluted run-off from slag dumps cause pollution of the surface water resources of adjacent landowners or impact on the productivity of irrigation lands due to salinisation of soils, these landowner's common law right to private ownership is being infringed and the industry runs a risk of claims for damages being instituted against them. The industries wrongful act is thus constituted by its omission to take pro-active steps to prevent polluted run-off originating on its property, and more particular the slag dumps, from polluting an adjacent landowner's surface- and groundwater and soil.

11.2.2 Fault

Fault is manifested when a wrongdoer or wrongdoing industry acted either intentionally or negligently, which action caused a third party to suffer personal or material damage. A claimant wishing to recover such financial loss suffered due to pollution, will therefore have to prove fault in any of these two forms on the side of the wrongdoing industry (Joubert *et al*, 1995; Neethling *et al*, 1992; Potgieter & Visser, 1993).

An aggrieved party can satisfy the requirement of negligence by establishing that a "reasonable person" in the position of the wrongdoing industry (i) would foresee the reasonable possibility of his conduct causing damage or harm to another person or property and causing such person patrimonial loss; (ii) that reasonable steps should have been taken to guard against the occurrence of such loss or damage and (iii) that the industry failed to take the necessary steps to guard against the occurrence of such damage or harm (Neethling *et al*, 1992). An objective test, the test of the so called "reasonable man" or reasonable person, is applied to establish whether a "reasonable person" would have acted differently under the same circumstances and if the damage caused by environmental pollution originating from slag dumps was reasonably foreseeable and avoidable (Joubert *et al*, 1995; Neethling *et al*, 1992; Potgieter & Visser, 1993).

Although issues like the specific characteristics of a "reasonable man" and the legal limits of the concepts of foresee ability and avoid ability are questionable, it can be submitted that an industry, which includes a steel industry, is normally indeed in a position to foresee the reasonable possibility of damage being caused and that this would justify the required element of negligence in order for the Aquilian action to succeed.

Although it may seem unthinkable that an individual or group from any industry would act intentionally to cause damage to another party, this would be the case where a steel industry anticipates the possibility that the disposal of slag on dumps may be harmful for human health or the environment or damaging to the property of third parties, but reconcile itself with such a possibility by allowing the disposal to take place.

11.2.3 A link between the conduct and the damages sustained or causation

The aggrieved party or claimant will, in order to succeed with a claim for damages, have to prove a nexus or a link between the delictual act or damage causing event and the damages suffered (Joubert *et al*, 1995; Neethling *et al*, 1992; Potgieter & Visser, 1993).

Causation will have to be proved where surface water is, for example, polluted by contaminated runoff from nearby slag dumps and the irrigation of agricultural lands with this water cause soil quality to deteriorate to the extent that the crop yield is significantly reduced and financial losses are suffered. However, no legal system holds a wrongdoing industry liable without limitation for all the harmful consequences suffered by the aggrieved party and some means must be found to limit its liability (Neethling *et al,* 1992). The criteria of "reasonable foresee ability" has been applied by the courts in a number of instances and the moment of causing the damage is relevant to determine reasonable formability.

Direct and consequential damages are therefore distinguished for the purpose of limiting liability-making compensation for consequential loss often irrecoverable because of the remoteness thereof. Direct loss refers to the immediate or direct consequence of a damage-causing event, while consequential loss is damage that flows from such loss. An example of a situation where the material damages suffered will be too remote, is the case where a landowner irrigates his agricultural lands with water originating from a surface water source which is being polluted by contaminated run-off from slag dumps from a steel industry in the vicinity of his property. The financial loss suffered because of the reduction in the production capacity due to soil contamination will constitute direct damage making it recoverable from the wrongdoing and liable industry. But should the landowner not be able to pay off his bond as a result of his "financial depression", the interest incurred will constitute indirect damages and will not be recoverable due to the remoteness thereof and its unforeseeability at the time of the pollution-causing event. Damage will not be recoverable from a steel industry if the damages were not foreseeable or were too remote.

11.2.4 Damages

Damage is measured as the loss in value of an article or property as a result of a wrongful act or conduct which, in the case of a steel industry, is caused by environmental pollution resulting from its slag disposal activities. The rationale for an action for damages is to place the aggrieved or affected party in the hypothetical position he would have been in, had the pollution-causing event not taken place (Joubert *et al*, 1995; Neethling *et al*, 1992; Potgieter & Visser, 1993).

The amount of damages is established by measuring the reasonable costs to restore the property to its original state, or the difference between the value of the property before and after the pollution-causing event occurred (Potgieter & Visser, 1993). Damages may also be claimed for the fact that property could not have been employed to make a profit, for example due to degradation of soils or irrigation sources.

In the event of personal injuries resulting from the wrongful act, for example lung cancer due to dust pollution, the injured party will be entitled to claim for actual financial loss (for example medical and hospital expenses), pain and suffering and prospective loss such as future medical expenses for treatment an loss of future earnings (Potgieter & Visser, 1993).

11.3 Vicarious liability

Vicarious liability can be defined as "the liability of one party for a wrong committed by another." (Wicke, 1998, p.21).

In the event of an employee, agent or officer of a steel industry acting in the cause and scope of his or her employment and in so doing committing a wrongful act, for example not controlling pollution emanating from slag dumps, the employer is held liable for such damages (Joubert *et al*, 1995; Neethling *et al*, 1992; Wicke, 1998). A corporation can also incur criminal liability as a result of an offence by such a person (Lipman, 1997). Although the steel industry is not personally at fault in any way, the liability of the wrongdoing employee is imputed or transferred to the employer, the industry, who has a "deeper pocket" to compensate the aggrieved or injured party for his employee's negligence.

Providing some form of relief, a right of recourse is available to the industry against the defaulting employee, should a third party be successful with a claim for damages against the industry (Neethling *et al*, 1992). This will, however, only be the case where an employee was explicitly entrusted with the task of controlling or avoiding pollution emanating from slag dumps, but neglected to do so.

The three requirements constituting vicarious liability for the wrongful act of employees is the existence of a employer-employee relationship at the time of the wrongful conduct, the wrongful act should be committed by the employee and the employee should act in the course and scope of his employment (Joubert *et al*, 1995; Neethling *et al*, 1992; Wicke, 1998). It therefore follows that the steel industry will be held liable to compensate third parties who suffered material damages or impairment of physical health resulting from pollution caused by the disposal of slag on dumps. This will be the case even if an employee, entrusted with the task of managing the disposal of slag in a responsible way, neglected to carry out his duty with the proper care or in breach of his employment contract.

11.4 Interdict

11.4.1 Introduction

The court is normally approached with an application for an interdict in order to prevent harm to persons or property before it occurs, or to prevent the continuation of a present existing unlawful or damage-causing situation. On a urgent basis the court can be approached with the request to grant such an interdict to prohibit a defaulting industry from polluting the environment by controlling the pollution caused by slag dumps, or to take positive steps to rehabilitate the damages caused by such pollution.

The interdict can be sought to refrain or to stop a party from doing an unlawful act (a prohibiting interdict) or to impose a positive duty on a party to act in a specific way (a mandatory interdict). An example of such a mandatory interdict will be an instruction to abate the nuisance caused by dust emanating from slag dumps or slag disposal practices to local residents (Joubert et al, 1996). Should the industry's activities impact on the environment or the individual rights of adjacent landowners or downstream users of a watercourse, a prohibiting interdict can be sought by the aggrieved parties ordering the industry to discontinue certain activities to stop the present existing situation from continuing.

11.4.2 Elements of an interdict

A person seeking a speedy remedy where his or her right to a clean and healthy environment is threatened by polluted water originating from a steel industry's slag dumps, will have to satisfy the following elements in order to succeed with an application for an interdict:

- ***A clear right***

The aggrieved party seeking an interdict may rely on a right in terms of the substantive law, for example a common law right or a right of uninterfered ownership of property, or a constitutional right, for example the right to an environment free of pollution, in order to satisfy this element (Joubert *et al*, 1996)

- ***Damage or injury actually committed or reasonably apprehended***

The damage envisaged by this requirement refers to material damage to property or the environment or a person's health which have actually occurred or is reasonably apprehended to occur as a result of the use of polluted water emanating from slag dumps (Joubert *et al*, 1996).

- ***Absence of similar protection by any other remedy***

The court will not award an interdict in the case where an applicant can obtain adequate redress through the ordinary remedies such as an award of damages under the Aquilian action (Joubert *et al*, 1995)

12. CONCLUSION

Over and above the social and economic advantages associated with the production of steel, it also provides us with versatile and useful material to provide in an essential part of our daily lives. A number of by-products are also associated with the steel production process, including the by-product slag which is formed when material such as dolomite is used to purifies steel. Despite attempts to re-use slag material by using it for road construction and the manufacturing of concrete, a percentage is still discarded in the environment in the form of slag dumps. In this thesis specific attention was given to the environmental impacts specifically associated and caused by the disposal of slag on dumps and how government, as custodian of the country's resources, tries to manage these impacts through the introduction of environmental legislation, -guidelines and -standards. As a result of the study, the following can be concluded with specific reference to the disposal of slag produced by an iron- and steel industry.

The popular demand for steel products in South Africa has resulted in the development of the country as one of the leading steel producers in the world. On a global scale South Africa is currently ranked as the 21^{st} largest supplier of steel. The study area was confined to the South African steel picture, with specific reference being given to the leading steel manufacturing industries in the country, their location and the range of their products. These industries include Iscor, Columbus-, Highveld and Davsteel and it can subsequently by concluded that Iscor, operating steel plants in Vanderbijlpark, Vereeniging and Newcastle, is the largest producer of steel in the country and on the continent. These industries collectively provide for the local and overseas demand for products ranging from building material, motor vehicles and -parts and household appliances to machinery and packaging.

The reference to the iron- and steel manufacturing process was aimed at indicating the origin and composition of slag. It is concluded that the use of dolomite and limestone as fluxing agents to remove impurities from molten iron and steel results in the formation of the by-product slag when cooled down. The basic sources of slag are thus identified as the blast furnace, electric arc furnace and the basic oxygen furnace, together producing a total of 455 kg slag for every one ton of steel produced and resulting in more than 11 million tons of slag produced from 1996 to 1998. Depending on the chemical properties and texture of slag, it can be re-used in a number of ways which include the use as agricultural fertilizer, road construction and a component of concrete, but a large percentage is being discarded on the premises of steel plants as slag dumps.

It was further concluded that the total volume of slag produced (on average 3,5 million tons per annum), together with its chemical composition, determine the impact that the presence of slag dumps have on the environment. The chemical properties of slag are determined by the chemical composition of the raw materials used and can be established by using the TCLP or Acid Rain tests. Both these tests simulate the formation of seepage and leach ate through a dump and allow for the chemical analyses of these monsters. The chemical substances associated with slag dumps identified in a number of studies include, inter alia, aluminum, agron, calcium oxide, fluor-spar, iron, lead, magnesium oxide, manganese oxide, nickel, phoshorus, selenium, silicon oxide and sulphur.

The environmental impacts generally associated with the presence of slag dumps include surface- and groundwater pollution, which also leads to a lowering in the quality of soil, air pollution due to the formation of dust by winds and the fact that the general aesthetics of the area is spoiled by the presence of mountainous piles of slag dumps. It was concluded that water pollution is the most significant environmental impact associated with the disposal of slag on dumps and therefore required more stringent control by government through DWAF who acts as custodian of the country's water resources. Certain chemical substances present in a water body can be elevated to unacceptable levels when leach ate or seepage originating from surrounding slag dumps reaches the water body. The DWAF established such acceptable levels through the implementation of the Target Water Quality Guidelines and when the chemical substances associated with slag dumps exceed these values, the quality of the water body is affected by making it unfit for its intended use. It follows that pollutants originating from slag dumps and reaching nearby water resources may leave such a water resource not suitable for domestic-, industrial-, aquatic- and agricultural use. These impacts include, inter alia, the scaling of household equipment, neurological disorders in human consumers, the lowering of crop yield and quality, a reduction in productivity and respiratory distress in aquatic organisms to name a few.

The government, in terms of its Constitutional mandate, aims to regulate all environmental impacts, including those associated with the disposal of slag, in order to secure a pollution free environment not harmful to our health and well being by adopting a number of environmental laws. For this purpose a number of framework legislation, which includes the Environmental Conservation Act and the National Environmental Management Act, were adopted to secure the goals of environmental management and the management of slag disposal practices in a broad and principal based way. The source and impact specific legislation of particular importance to a steel industry as far as its disposal of slag is concerned were identified and include the National Water Act, certain sections of the Environment Conservation Act and the Atmospheric Pollution Prevention Act, as well as departmental guideline documents such as the DWAF's Water Quality Guidelines and Waste Management Series.

It follows that the National Water Act places a duty on a steel industry, whose slag disposal practices pose a threat to water resources, to control this pollution causing practice by taking the appropriate steps to prevent this pollution from occurring, continuing or recurring. If not, the DWAF can take such preventative or rehabilitative steps themselves and recover the costs thereof from the polluter or any other party who benefited from it.

It can furthermore be concluded that the disposal of slag by a steel industry will not be allowed without having been permitted to do so in terms of section 20 of the Environmental Conservation Act. Its follows that slag should first be classified to determine its hazardousness and to establish the type of landfill to be constructed for the purpose of disposing slag. A permit will only be granted by the DWAF once they are satisfied that the requirements set out in the Minimum Requirements Documents are met.

If a steel industry's plant is located within the boundaries of a dust control area, as indicated by the Minister in terms of the Atmospheric Pollution Act, such an industry will have to take precautionary steps to ensure that dust emanating from slag dumps does not create a nuisance to residents in the area of the dumps. Failing to do so the Chief Officer may serve an abatement notice on such a industry to avoid such nuisance.

It is clear that, over and above the regulatory power of legislation, private individuals may still safeguard their environmental rights by claiming compensation from a steel industry for damage caused to property or health caused by pollution originating from slag dumps, providing that all the elements of such a delict was present. Private individuals, such as residents, may also apply for an interdict to prevent any harm to person and property from materialising as a result of pollution from slag dumps, providing that the elements of an interdict are being satisfied.

The environment has, in recent years, received international and local priority, putting those activities of man which pose a risk to the environment high on the agenda. The indiscriminate disposal of slag by steel industries are, for this reason, also targeted and managed by the flood of environmental management principles, -policies, programs and legislation introduced by government in recent years. Its main purpose to secure the objectives of environmental management, namely to mitigate the negative impacts of human activities on the environment and to enhance its positive impacts to ultimately ensure that there is more for all of us forever.

13. REFERENCES

Anon. 1998: Overview of Iscor flat products, Vanderbijlpark works. http://www.iscorltd.colza

Atmospheric Pollution Prevention Act 45 of 1965

Barnard, D. 1999: Environmental law for all. Impact books: Pretoria.

Baxter, L. 1991: Administrative law. Juta: Cape Town.

Bethlehem, L. & M. Goldblatt. 1997: The bottom line: Industry and the environment in South Africa. University of Cape Town Press: Rondebosch.

Chapelle, H.F. 1997: Hidden sea, groundwater, springs and wells. Geoscience Press: Tuscon.

Constitution of the Republic of South Africa Act 108 of 1996

Cunningham, P.W. & B.W. Siago. 1997: Environmental Science: A global concern (4th edition) W.M.C Brown Publishing: Dubuque.

Department of Water Affairs and Forestry. 1996: South African water quality guidelines – Domestic use. (Second edition) DWAF: Pretoria.

Department of Water Affairs and Forestry. 1996: South African water quality guidelines – Agricultural use – Irrigation (Second edition) DWAF: Pretoria.

Department of Water Affairs and Forestry. 1996: South African water quality guidelines – Recreational use (Second edition) DWAF: Pretoria.

Department of Water Affairs and Forestry. 1998: Focus on using and protecting water resources. Water Act News. www.dwaf.pwv.gov.za/newsletters/wateractnew//page1.

Department of Water Affairs and Forestry. 1998: Minimum requirements for the handling, classification and disposal of hazardous waste. (second edition). DWAF: Pretoria.

Department of Water Affairs and Forestry. 1998: Minimum requirements for, waste disposal by landfill. (second edition). DWAF: Pretoria.

Department of Water Affairs and Forestry. 1998: Minimum requirements for water monitoring at waste management facilities. (second edition). Department of Water Affairs and Forestry: Pretoria.

Edington, J. 1997: The new world of steel. Ironmaking and steelmaking, 24 , 19 – 28.

Environment Conservation Act 73 of 1989

Fourie, O. 1999: Personal communication: Ockie Fourie Toxicologists, Pretoria.

Fuggle, R.S. & M.A. Rabie. 1992: Environmental Management in South Africa. Juta: Cape Town.

Goldring, D.C & L.M Juckes. 1997: Petrology and stability of steel slags. Ironmaking & Steelmaking, 24 , 447 – 455.

Government Notice 1986 of 24 August 1990

Industrial Development Corporation. 1999: Industry analysis: Downstream steel products. Industrial Development Corporation: Sandton.

International Iron and Steel Institute & United Nations Environmental Programme – Industry and Environment, 1997: Steel industry and the Environment: Technical and management issues. Ceuterick: Belgium.

International Iron and Steel Institute, 1999: Largest steel producing countries: 1992 – 1998.

http://www.worldsteel.org/treAnds – indicators/countries.html

Ji, F.Z, Du Sichen & S. Seetharaman. 1998: Experimental studies of viscosities in FenO – MgO – SiO2 and FenO – MnO – SiO2 slags. Ironmaking & Steelmaking, 25, 309 – 315.

Joubert, W.A., J.A. Farris & L.T.C Harms. 1995: The law of South Africa. (First reissue) Vol 8 Part 1 Butterworths: Durban.

Joubert, W.A., J.A. Farris & L.T.C Harms. 1996: The law of South Africa. (First reissue) Vol 9 Butterworths: Durban.

Joubert, W.A., J.A. Farris & L.T.C Harms. 1998: The law of South Africa. (First reissue) Butterworths: Durban.

Kidd, M. 1997: Environmental law – a South African guide. Juta: Kenwyn.

Lipman, Z. 1997: Corporations, crime and the environment. South African Journal for environmental law and policy, 4, 69 – 90.

Loots, C. 1997: The impact of the Constitution on environmental law. South African Journal for environmental law and policy, 4, 57 – 68.

Meraikib, M. 1997: Activity of silica in blast furnace slags. Ironmaking & Steelmaking, 24, 401 – 405.

Meraikib, M. 1997: Partition of sulphur and manganese between blast furnace slag and hot metal. Ironmaking & Steelmaking, 24, 230 – 238.

Miller,G.T. 1996: Living in the environment. Wadsworth: California.

Minerals Act 50 of 1991

Mines and Works Act 27 of 1956

Mitchell, F, D. Sleeman, J.A Duffy, M.D. Ingram & R.W. Young. 1997: Optical basicity of metallurgical slags: new computer based system for data visualisation and analysis. Ironmaking & Steelmaking, 24, 306 – 312.

National Environmental Management Act 107 of 1998

National Water Act 36 of 1998

Neethling, J, J.M. Potgieter & P.J. Visser. 1992: Deliktereg (Tweede uitgawe) Butterworths: Durban.

Nolte, C.C. 2000: Personal communication; Environmental Manager, Iscor, Pretoria.

Nzotta, M.M., Du Sichen & S. Seetharaman. 1999: Sulphide capacities of FeO –SiO2, CaO – FeO and FeO – MnO slags. Ironmaking & Steelmaking, 39, 657 – 665.

Nzotta, M.M., R. Nilsson, Du Sichen & S. Seetharaman. 1997: Sulphide capacities in MgO – SiO2 and CaO – MgO – SiO2 slags. Ironmaking & Steelmaking, 24, 300 – 304.

Potgieter, J.M. & P.J. Visser. 1993: Law of damages. Juta: Kenwyn.

Pretoria City Council v de Jager 1997(2) SA 46 (A)

Prinsloo, P.J.J. (Prof). 1993: Yskor Vanderbijlpark werke, 1943 – 1993. (Proefskrif) Potchefstroomse Universiteit vir Christelike Hoer Onderwys: Vaaldriehoekkampus.

Shahbazien, F, Du Sichen & S. Seetharaman. 1999 . Viscosities of some fayalitic slags containing CaF2. International Steel &Iron Journal, 39, 687 – 696.

Shahbazien, F, Du Sichen, K.C. Mills & S. Seetharaman. 1999: Experimental studies of viscosities of some CaO – CaF2 – SiO2 slags. Ironmaking & Steelmaking, 26, 193 – 199.

Shearer, B. (Hydrogeology Group: British Geological Survey). 1999: Groundwater pollution – a problem in store. http://www.bgo.ac.uk/bgs/w3/hydro/PollProb.htm

South African Iron & Steel Institute, 1999: Overview of the South African steel industry. http://www.saisi.co.za/statistics.html

Southwood, I. 1998: Legitimate expectation: a case of paradigm lost? SAPR/PL, 13, 197 – 216.

Statistics South Africa. 1999: http://www.statssa.gov.za

Stein, R. 1997: Regulation of waste management in South Africa – a case for integration. South African Journal for environmental law and policy, 253 – 268.

Susa, M. & K. Nagata. 1997: Mathematical model for ion refractivity of oxygen in slags. Ironmaking & Steelmaking, 24, 239 – 241.

Wicke, H. 1998: Vicarious Liability: Not simply a matter of legal policy. Stellenbosch Law Review, 1, 21 – 43.

Wilson, C. 1999: Personal communication: Water Quality Manager, Iscor, Newcastle.