forestry, fisheries
& the environment

Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

# APPLICATION FORM FOR EXCLUSION OF WASTE STREAM OR PORTION OF WASTE STREAM FROM THE DEFINITION OF WASTE IN TERMS OF GN 715 OF 18 JULY 2018.

| | |
|---|---|
| | (For official use only) |
| File Reference Number: | 12/9/11 |
| NEAS Reference Number: | |
| Date Received: | |

Application for exclusion of waste stream or portion of waste stream in terms of the National Environmental Management: Waste Act, 2008(Act No.59 of 2008), as amended.

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**Kindly note that:**

1. This application form is current as of 18 July 2018. It is the responsibility of the applicant to ascertain whether subsequent versions of the form have been published or produced by the competent authority.

2. The application must be typed within the spaces provided in the form. The sizes of the spaces provided are not necessarily indicative of the amount of information to be provided. Spaces are provided in tabular format and will extend automatically when each space is filled with typing.

3. Where applicable **black out** the boxes that are not applicable in the form.

4. Incomplete applications may be returned to the applicant for revision.

5. The use of the phrase “not applicable” in the form must be done with circumspection. Should it be done in respect of material information required by the competent authority for assessing the application, it may result in the refusal of the application as provided for in the Regulations.

6. This application must be handed in at the offices of the relevant competent authority as determined by the Act and regulations.

7. Unless protected by law, all information filled in on this application will become public information on receipt by the competent authority. Any interested and affected party should be provided with the information contained in this application on request, during any stage of the application process.

**Queries must be addressed to the contact hereunder:**

**Departmental Details**

**Postal address:**
Department of Environment, Forestry and Fisheries
Attention: Director: Licensing
Private Bag X447
Pretoria
0001

**Physical address**:
Department of Environment, Forestry and Fisheries
Environment House (473 Steve Biko Rd, corner Steve Biko and Soutpansberg Rds)
Arcadia X6
PRETORIA
0002

Application queries should be directed to the Directorate: Licensing on:

Tel : 012 3999 791 Email: Lmahlangu@environment.gov.za

**COMMENCEMENT: Has the activity (ies) commenced:** No

**If yes, When (provide the Year, Month and Date):** [redacted]

**WASTE STREAM/PORTION OF WASTE STREAM**

Zinc Ash, and Zinc Dross

**BENEFICIAL USE**

Manufacturing of Zn commodities – zinc oxide (ZnO) and zinc sulphate ($ZnSO_4$).

*Zinc Dross* and *Zinc Ash* are waste products derived from the hot dip galvanizing process and are valuable input materials for the manufacturing of metallic Zn (Rudnik, 2020).

## SITE GPS CO-ORDINATES

Please provide the geographic co-ordinates of **all corners** of the waste generating site; in degrees, decimal minutes, and seconds for all sites (Indicate the position of the activity using the latitude and longitude of the centre point of the site for each alternative site). Provide geographic coordinates for all corners of the facility (ies) ONLY THE FORMAT PRESCRIBED (e.g. $60^{0}$ 29' 30" Latitude; $34^{o}$ 20' 15" Longitude)

| FACILITY | CORNER | LATITUDE | | | LONGITUDE | | |
|---|---|---|---|---|---|---|---|
| **1 Transvaal Galvanisers (Pty) Ltd** | 1 | 26 | 23 | 59.85” | 28 | 28 | 48.41" |
| **Batch HDG** | 2 | 26 | 24 | 1.64” | 28 | 28 | 51.52" |
| | 3 | 26 | 24 | 3.71" | 28 | 28 | 50.04" |
| | 4 | 26 | 24 | 1.92" | 28 | 28 | 46.90" |
| **Dragline HDG Plant** | 1 | 26 | 24 | 2.89" | 28 | 28 | 51.66" |
| | 2 | 26 | 24 | 5.79" | 28 | 28 | 55.91" |
| | 3 | 26 | 24 | 6.45" | 28 | 28 | 55.43" |
| | 4 | 26 | 24 | 3.76" | 28 | 28 | 50.93" |
| **2 Armco Superlite** | 1 | 26 | 8 | 8.33" | 28 | 12 | 36.71" |
| | 2 | 26 | 8 | 11.27" | 28 | 12 | 36.61" |
| | 3 | 26 | 8 | 11.29" | 28 | 12 | 36.02" |
| | 4 | 26 | 8 | 8.30" | 28 | 12 | 36.09" |
| **3 Armco Superlite (Randfontein)** | 1 | 26 | 11 | 54.59” | 27 | 41 | 43.51” |
| | 2 | 26 | 11 | 55.21” | 27 | 41 | 44.83” |
| | 3 | 26 | 11 | 55.61” | 27 | 41 | 44.57” |
| | 4 | 26 | 11 | 54.99” | 27 | 41 | 43.29” |
| **4 Silverton Engineering** | 1 | 25 | 43 | 26.50” | 28 | 17 | 53.12” |
| | 2 | 25 | 43 | 28.67” | 28 | 17 | 53.81” |
| | 3 | 25 | 43 | 28.72” | 28 | 17 | 53.09” |
| | 4 | 25 | 43 | 26.62” | 28 | 17 | 52.47" |
| **5 SMT Group** | 1 | 26 | 12 | 18.06 | 28 | 18 | 07.55 |
| | 2 | 26 | 12 | 17.77 | 28 | 18 | 08.05 |
| | 3 | 26 | 12 | 18.14 | 28 | 18 | 08.37 |
| | 4 | 26 | 12 | 18.44 | 28 | 18 | 07.80 |
| **6 Galferro Galvanisers** | 1 | 26 | 16 | 29.42 | 28 | 23 | 53.89 |
| | 2 | 26 | 16 | 25.85 | 28 | 23 | 54.42 |
| | 3 | 26 | 16 | 26.02 | 28 | 23 | 55.95 |
| | 4 | 26 | 16 | 29.52 | 28 | 23 | 55.41 |
| **7 Lianru Galvanisers** | 1 | 26 | 24 | 04.10 | 28 | 28 | 30.22 |
| | 2 | 26 | 24 | 05.35 | 28 | 28 | 32.40 |
| | 3 | 26 | 24 | 06.76 | 28 | 28 | 31.41 |
| | 4 | 26 | 24 | 05.51 | 28 | 28 | 29.20 |
| **8 Pro-Tech Galvanizers (Pty) Ltd** | 1 | 26 | 23 | 47.81 | 28 | 28 | 27.01 |
| | 2 | 26 | 23 | 47.56 | 28 | 28 | 44.09 |
| | 3 | 26 | 23 | 49.40 | 28 | 28 | 44.47 |
| | 4 | 26 | 23 | 49.61 | 28 | 28 | 43.01 |

| FACILITY | CORNER | LATITUDE | | | LONGITUDE | | |
|---|---|---|---|---|---|---|---|
| **9 Agrico** | 1 | 26 | 10 | 33.23 | 26 | 09 | 51.74 |
| | 2 | 26 | 10 | 33.97 | 26 | 09 | 53.86 |
| | 3 | 26 | 10 | 33.41 | 26 | 09 | 54.10 |
| | 4 | 26 | 10 | 35.30 | 26 | 09 | 59.44 |
| | 5 | 26 | 10 | 36.41 | 26 | 09 | 58.96 |
| | 6 | 26 | 10 | 33.79 | 26 | 09 | 51.47 |
| **10 Galvanising Techniques** | 1 | 33 | 54 | 15.61 | 25 | 36 | 49.89 |
| **(Metalman Pty Ltd)** | 2 | 33 | 54 | 15.13 | 25 | 36 | 47.12 |
| | 3 | 33 | 54 | 13.58 | 25 | 36 | 47.50 |
| | 4 | 33 | 54 | 14.04 | 25 | 36 | 50.27 |
| **11 Sable Sands t/a** | 1 | 32 | 55 | 20.54 | 27 | 41 | 45.89 |
| **Morhot Galvanizers** | 2 | 32 | 55 | 20.29 | 27 | 41 | 50.67 |
| | 3 | 32 | 55 | 20.85 | 27 | 41 | 50.75 |
| | 4 | 32 | 55 | 21.27 | 27 | 41 | 45.94 |
| **12 Pinetown Galvanizing** | 1 | 29 | 48 | 56.75 | 30 | 49 | 19.19 |
| | 2 | 29 | 48 | 58.29 | 30 | 49 | 19.12 |
| | 3 | 29 | 48 | 58.09 | 30 | 49 | 17.77 |
| | 4 | 29 | 48 | 56.47 | 30 | 49 | 18.72 |
| **13 Durban Galvanizing** | 1 | 29 | 47 | 48.03 | 30 | 00 | 38.23 |
| **(Plant ‘A’)** | 2 | 29 | 47 | 49.73 | 30 | 00 | 40.72 |
| | 3 | 29 | 47 | 50.23 | 30 | 00 | 40.22 |
| | 4 | 29 | 47 | 48.56 | 30 | 00 | 37.77 |
| **14 Durban Galvanizing** | 1 | 29 | 43 | 10.28 | 31 | 00 | 00.13 |
| **(Plant ‘B’)** | 2 | 29 | 43 | 06.72 | 31 | 00 | 04.02 |
| | 3 | 29 | 43 | 07.18 | 31 | 00 | 04.52 |
| | 4 | 29 | 43 | 10.69 | 31 | 00 | 00.66 |
| **15 KZN Galvanizers** | 1 | 29 | 35 | 35.62 | 30 | 24 | 45.75 |
| | 2 | 29 | 35 | 36.70 | 30 | 24 | 45.86 |
| | 3 | 29 | 35 | 36.77 | 30 | 24 | 45.54 |
| | 4 | 29 | 35 | 35.74 | 30 | 24 | 45.19 |
| **16 Bay Galvanisers** | 1 | 28 | 44 | 36.20 | 32 | 02 | 07.17 |
| | 2 | 28 | 44 | 35.15 | 32 | 02 | 07.75 |
| | 3 | 28 | 44 | 35.34 | 32 | 02 | 08.20 |
| | 4 | 28 | 44 | 36.38 | 32 | 02 | 07.63 |
| **17 Advanced Galvanising (Pty) Ltd** | 1 | 33 | 55 | 29.59 | 18 | 38 | 11.37 |
| | 2 | 33 | 55 | 29.63 | 18 | 38 | 13.89 |
| | 3 | 33 | 55 | 31.11 | 18 | 38 | 13.96 |
| | 4 | 33 | 55 | 31.12 | 18 | 38 | 11.39 |
| **18 South Cape Galvanizing (Pty) Ltd** | 1 | 33 | 58 | 46.29 | 22 | 27 | 10.13 |
| | 2 | 33 | 58 | 46.37 | 22 | 27 | 12.16 |
| | 3 | 33 | 58 | 47.05 | 22 | 27 | 12.12 |
| | 4 | 33 | 58 | 46.97 | 22 | 27 | 10.06 |

forestry, fisheries
& the environment

Department:
Forestry, Fisheries and the Environment
**REPUBLIC OF SOUTH AFRICA**

## 1. BACKGROUND INFORMATION

| | | | |
|---|---|---|---|
| **Applicant:** | Hot Dip Galvanizers Association of Southern Africa (HDGASA) | | |
| **Trading name (if any):** | - | | |
| **Contact person:** | Robin Clarke<br>Executive Director; Hot Dip Galvanizers Association Southern Africa | | |
| **Physical address:** | Bedfordview Office Park, Building 1, 3 Riley Road Bedfordview | | |
| **Postal address:** | P.O. Box 2212, Edenvale, 1610 | | |
| **Postal code:** | 1610 | | |
| **Telephone:** | 011 456 7960 | Cell: | 082 902 5119 |
| **E-mail:** | robin@hdgasa.org.za | Fax: | |
| **SAWIS registration number:** | Transvaal Galvanizers – GPG -01- 711<br>Armco Isando – GPG-050091<br>Armco Randfontein – GPG – 05-092<br>SMT – GPG – 09 – 470<br>Lianru – GPG – 08 -873<br>Galvanizing Techniques – D 00927-01<br>Durban Galvanizing – D 02296-01<br>KZN galvanizers (Pietermaritzburg) - D 15650-01<br>Advanced Galvanizing (Cape Town) – D 07273- 01 | | |
| **Nearest town or districts:** | 1. Nigel, Gauteng<br>2. Kempton Park, Gauteng<br>3. Randfontein, Gauteng<br>4. Pretoria, Gauteng<br>5. Benoni, Gauteng<br>6. Springs, Gauteng<br>7. Nigel, Gauteng<br>8. Nigel, Gauteng<br>9. Lichtenburg, North West<br>10. Port Elizabeth, Eastern Cape<br>11. Mdantsane, Eastern Cape<br>12. Pinetown, Kwazulu Natal<br>13. Durban, Kwazulu Natal<br>14. Pietermaritzburg, Kwazulu Natal<br>15. Richards Bay, Kwazulu Natal<br>16. Cape Town, Western Cape<br>17. George, Western Cape | | |

## 2. DETAILED DESCRIPTION OF WASTE GENERATING PROCESS (Attach supporting illustrations)

| **Supporting documents attached?** | **Yes** | **No** |
|---|---|---|
| Production Process Flow Chart | ☒ | |
| Waste Classification | ☒ | |
| Chemical and technical specification (pre-beneficiation) | ☒ | |
| Chemical and technical specification (post beneficiation) (MSDS) | ☒ | |
| Risk Assessment Report | ☒ | |
| Risk Management Plan | ☒ | |

## 3. DECLARATIONS

3.1 The Applicant

X I, ROBIN JOHN CLARKE declare that I -

- am, or represent[1], the applicant in this application;
- will provide the Minister with access to all information at my disposal that is relevant to the application;
- will be responsible for the costs incurred, in respect of the undertaking of any process required in terms of the Regulations; and
- hereby indemnify the Government of the Republic, the competent authority and all its officers, agents and employees, from any liability arising out of the content of any report, any procedure or any action which the applicant is responsible for in terms of these Regulations;
- will perform all other obligations as expected from an applicant in terms of the Regulations;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 14(1) of these regulations and is punishable in terms of regulation 14(2) of these Regulations.

X R. J Clarke.

Signature of the applicant[2]/ Signature on behalf of the applicant:

X HOT DIP GALVANIZERS ASSOCIATION OF SOUTHERN AFRICA

Name of company (if applicable):

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[1] If this is signed on behalf of the applicant, proof of such authority from the applicant must be attached.

[2] If the applicant is a juristic person, a signature on behalf of the applicant is required as well as proof of such authority.

x 4 July 2023. 6 July 2023
Date:

x 1360556 Sgt Ndufova
Signature of the Commissioner of Oaths:

x Reuben Rhefa Ndufova
Name of the Commissioner of Oaths:

x 2023/07/06
Date:

x Sergeant
Designation:

Official Stamp:

SUID-AFRIKAANSE POLISIEDIENS
SAPS LYTTELTON
2023 -07- 06
COMMUNITY SERVICE CENTRE
SOUTH AFRICAN POLICE SERVICE

**References:**

Cakmak, I., 2009. Enrichment of fertilizers with zinc: An excellent investment for humanity and crop production in India. **Journal of Trace Elements in Medicine and Biology.** 23(2009) p281–289. Elsevier

Direct quote on page 281: *“Micronutrient malnutrition is a growing concern in the developing world, resulting in diverse health and social problems, such as mental retardations, impairments of the immune system and overall poor health. In recent years, the zinc (Zn) deficiency problem has received increasing attention and appears to be the most serious micronutrient deficiency together with vitamin A deficiency. Zinc deficiency is particularly widespread among children and represents a major cause of child death in the world. In countries where Zn deficiency is well documented as an important public health problem, cereal-based foods are the predominant source of daily calorie and protein intake. Because the concentration of Zn in cereal crops is inherently very low, growing cereals on potentially Zn-deficient soils further decreases grain Zn concentrations. It is, therefore, not surprising that high Zn deficiency incidence in humans occurs predominantly on areas where soils are deficient in plant-available Zn, as shown in many Southeast Asian countries.”*

Rudnik, E.; 2020. Hydrometallurgical recovery of zinc from industrial hot dipping top ash. **Transactions of Non-ferrous Society of China**. 30(2020) p2239−2255. Elsevier

Direct quote on page 2240: *“The waste materials contain high percentage of zinc, i.e. 95%−98% in the bottom dross [1,3−6] and 60%−90% in the zinc ash [1,4,7], being valuable sources of secondary metal.”*

“[1] MASS P, PEISSKER P. Handbook of hot-dip galvanization [M]. Weinheim: Wiley, 2011.

[3] TRPČEVSKÁ J, HLUCHÁNOVÁ B, VINDT T, ZORAWSKI W, JAKUBÉCZYOVÁ D. Characterization of the bottom dross formed during batch hot-dip galvanizing and its refining [J]. Acta Metallurgica Slovaca, 2010, 16(3): 151−156.

[4] SCHMITZ D, FRIEDRICH B. In-house recycling of hard zinc and zinc ash by liquid metal centrifugation [C]//Proceedings of EMC. Düsseldorf, Germany: GDMB, 2007: 1−20.

[5] VOURLIAS G, PISTOFIDIS N, STERGIOUDIS G, POLYCHRONIADIS E K. A negative effect of the insoluble particles of dross on the quality of the galvanized coatings [J]. Solid State Science, 2005, 7(4): 465−474.

[6] BLAŠKOVÁ K, TRPČEVSKÁ J, PIROŠKOVÁ J, LAUBERTOVÁ M. Zinc waste treatment originated during hot-dip galvanizing [J]. World of Metallurgy—Erzmetall, 2017, 70(4): 223−226. [7] BAKARAT M A. Pyrometallurgical processing of zinc ash and flue dust [J]. Acta Metallurgica Slovaca, 2003, 9(4): 259−269.”

## WASTE GENERATING PROCESS:

### Hot Dip Galvanizing

Hot dip galvanizing is a metallurgical process that results when “perfectly” cleaned steel is immersed into molten zinc at approximately 450°C. The zinc protection coating is achieved by way of a chemical reaction between the molten zinc and the steel, forming a series of zinc iron alloys that provide a “chemical bond” between the steel and the protective coating. (*Source: Hot Dip Galvanized Information Sheet No.5 Hot Dip Galvanizing compared to Zinc Thermal Spray HDGASA, Information Sheets*).

Before the coating is applied, the steel is cleaned to remove all oils, greases, soils, mill scale, and rust. The cleaning cycle usually consists of a degreasing step, followed by acid pickling to remove scale and rust, and fluxing, which inhibits oxidation of the steel before dipping in the molten zinc.

The hot dip galvanizing process generate Zinc Ash and Zinc Dross, currently defined as waste in terms of the National Environmental Management Waste Act, Act 59 of 2008, Schedule 3.

i. Zinc ash is generated from surface oxidation of the galvanizing bath, and
ii. Zinc dross is a mix of zinc and iron that accumulates at the bottom of the galvanizing bath.

## GALVANISING PRODUCTION PROCESS FLOW

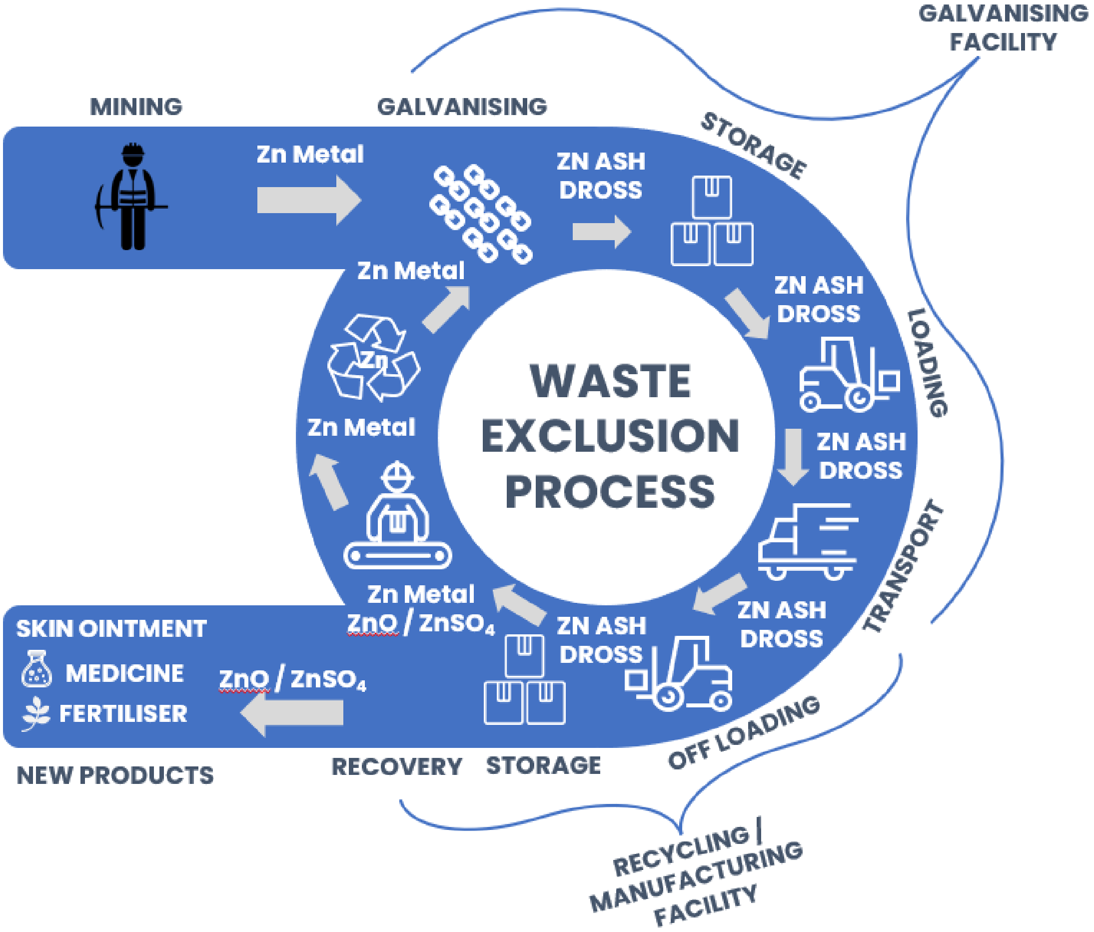
## (DROSS AND ASH GENERATED STEP 7)

| INPUT | PROCESS FLOW | OUTPUT | BENEFICIAL USE (OF IDENTIFED "WASTE EXCLUSION" PRODUCTS) |
|---|---|---|---|
| | **Step 1**<br>Steel articles received for galvanising | | |
| Hooks and wire | **Step 2**<br>Jigging | | |
| Heat<br>Alkaline degreasing agent<br>Wetting agents<br>Water | **Step 3**<br>Degrease (caustic bath) | Water vapour<br>Spent liquid (Alkaline)<br>Low volume of sludge | |
| Top up water | Water Rinse | | |
| Dilute HCl<br>Water | **Step 4**<br>Acid cleaning (Pickling) | Water vapour<br>Acid fumes<br>Spent Liquid Acid - As a result, iron salts are created and the acid bath content loses its properties and as a result Spent Pickle Liquor (SPL) is formed | To recycle / regenerate |
| Clean water | Water Rinse | | |
| Water<br>Zinc chloride<br>Ammonium chloride | **Step 5**<br>Stripping for galvanising | Zinc rich spent acid to zinc chemical production | |
| | **Step 6**<br>Flux | Water vapour<br>Filter and regenerate<br>Occasional sludge removal (to waste) - Ferrous hydroxide collects at the bottom of the flux bath | |
| Heat<br>Zinc metal<br>Alloy elements Water | Drying<br>**STEP 7**<br>Hot dip galvanize at 440 -460ºC | Particulate emissions filtered before air emissions to atmosphere<br>Zinc ash and dross to recycling | Zinc ash "recycled" to generate zinc products<br>Zinc Dross "recycled" to generate zinc products |
| | **Step 8**<br>Inspect and despatch | Used wire to steel recycling<br>Hooks to be reused | |

Source: Generated from information The Galvanizing Process: Inputs, emissions, wastes and recycling flows https://www.galvanizing.org.uk/sustainable-construction/galvanizing-is-sustainable/environmental-aspects/

## GALVANISING / RECOVERY / RECYCLING PROCESS FLOW

## (PRODUCTS: ZINC METAL, ZINC OXIDE, ZINC SULPHATE)



# WASTE CLASSIFICATION, RISK ASSESSMENT AND RISK MANAGEMENT PLAN FOR THE EXCLUSION OF ZINC ASH AND DROSS FROM THE DEFINITION OF WASTE FOR BENEFICIAL USE

Report date: 31 July 2023

*Prepared for:*
HDGASA – Hot Dip Galvanizers Association of Southern Africa
3 Riley Rd, Bedfordview,
Johannesburg, 2007

*Prepared by:*
GIY Hydro (Pty) Ltd trading as AquiScience
Ockie Scholtz, *Pr.Sci.Nat*
*M.Sc Geohydrology*
136 Meyer Street
George

AQUISCIENCE
Specialist Hydrogeological and
Environmental Pollution
Assessments

# PROJECT DETAILS

| | |
|---|---|
| **Project Type** | Waste Classification, Risk Assessment and Risk Management Plan for the exclusion of zinc ash and dross from the definition of waste for beneficial use |
| **Client** | Hot Dip Galvaniser Association of South Africa |
| **Site/s** | 1 Transvaal Galvanisers (Pty) Ltd<br>2 Armco Superlite<br>3 Armco Superlite (Randfontein)<br>4 Silverton Engineering<br>5 SMT Group<br>6 Galferro Galvanisers<br>7 Lianru Galvanisers<br>8 Pro-Tech Galvanizers (Pty) Ltd<br>9 Agrico<br>10 Galvanising Techniques<br>11 Sable Sands t/a<br>12 Pinetown Galvanizing<br>13 Durban Galvanizing<br>14 Durban Galvanizing<br>15 KZN Galvanizers<br>16 Bay Galvanisers<br>17 Advanced Galvanising (Pty) Ltd<br>18 South Cape Galvanizing (Pty) Ltd |
| **Beneficial use** | Manufacturing of Zn commodities - zinc oxide & zinc sulphate |
| **Project Number** | AS-HDG-23-01-06 |
| **Compiled by** | Ockie Scholtz, *Pr.Sci.Nat* |
| **Report Status** | FINAL |
| **Report date** | 31 July 2023 |
| **Signature** | |

# EXECUTIVE SUMMARY

AquiScience was appointed by the Hot Dip Galvaniser Association of South Africa (“HDGASA”) for assistance with an application to exclude *zinc (Zn)-Ash* and *Zn-Dross*, generated by various galvanising bodies in South Africa from the definition of waste. The supporting report was compiled according to the requirements contained in the *Regulations Regarding the Exclusion of a Waste Stream or a Portion of a Waste Stream from the Definition of Waste* (GN 715 in GG 41777 of 18 July 2018). *Zinc Dross* and *Zinc Ash* as produced during the galvanising process are valuable input material for the manufacturing of zinc commodities - zinc oxide (ZnO) and zinc sulphate ($ZnSO_4$).

The report includes a Waste Classification (SANS10234), Waste Assessment (GNR 635), Risk Assessment in terms of Regulation 8 of the Waste Exclusion Regulations, and a Risk Management plan in terms of Regulation 10 of the Waste Exclusion Regulations.

The overall objective was to apply to the minister of Department of Forestry, Fisheries and the Environment (“DFFE”) to exclude the ash generated from the definition of “waste” as per the *Regulations* (GN 715 in GG 41777 of 18 July 2018*)* for beneficial use.

The scope of work entailed the following:

1. Risk assessment as per the Legislative Framework, to include:
    a. Waste classification.
2. Risk management plan.
3. Report based on 1 & 2 above.
4. Assistance with the application to the DFFE for consideration to exclude the ash from the definition of waste.

Recycling of secondary materials from industrial processes reduces amount of waste to be finally disposed. *Zn-Ash* and *Zn-Dross* can be manufactured into Zn commodities as it contain valuable Zn that can be recovered and reused, making them important from both economic and environmental points of view. Zinc (Zn) is one of a few metals which can be recycled at all stages of the production and usage. It is estimated that over 80% of Zn available for recycling is currently recycled, while up to 30–40% of zinc consumed comes from reclaimed Zn sources.

Zn is a tradable commodity and can improve sustainable consumption and divert waste from landfills by using the *Zn-Ash* and *Zn-Dross* waste materials (containing up to 99% of Zn) as a valuable source of secondary Zn. Zinc (Zn) dross and Zn ash are valuable input materials for producers of zinc oxide (ZnO) and zinc sulphate ($ZnSO_4$) products.

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# 1. INTRODUCTION

AquiScience was appointed by the Hot Dip Galvaniser Association of South Africa ("HDGASA") for assistance with an application to exclude Zinc Ash ("*Zn-Ash*") and Zinc Dross ("*Zn-Dross*") generated at facilities of the HDGSA from the definition of waste for beneficial use. The *Zn-Ash* and *Zn-Dross* produced during the galvanising process are valuable input material for the manufacturing of zinc (Zn) commodities, zinc oxide (ZnO) and zinc sulphate ($ZnSO_4$). The galvanising facilities generating the waste material are listed below. *Note that all the facilities use the same technology during the galvanising process. The coordinates for the respective facilities can be viewed in Appendix A and the waste exclusion application form accompanying this application.

1. Transvaal Galvanisers (Pty) Ltd Batch HDG Dragline HDG Plant
2. Armco Superlite
3. Armco Superlite (Randfontein)
4. Silverton Engineering
5. SMT Group
6. Galferro Galvanisers
7. Lianru Galvanisers
8. Pro-Tech Galvanizers (Pty) Ltd
9. Agrico
10. Galvanising Techniques (Metalman Pty Ltd)
11. Sable Sands t/a Morhot Galvanizers
12. Pinetown Galvanizing
13. Durban Galvanizing (Plant 'A')
14. Durban Galvanizing (Plant 'B')
15. KZN Galvanizers
16. Bay Galvanisers
17. Advanced Galvanising (Pty) Ltd
18. South Cape Galvanizing (Pty) Ltd

The application was compiled according to the requirements of the GN 715 in GG 41777 of 18 July 2018 (*Regulations Regarding the Exclusion of a Waste Stream or a Portion of a Waste Stream from the Definition of Waste*). Supporting documentation to the application include a Waste Classification and Assessment, Risk Assessment in terms of Regulation 8 of the Waste Exclusion Regulations and a Risk Management plan in terms of Regulation 10 of the Waste Exclusion Regulations.

## 1.1 Background on HDGASA and the Hot Dip Galvanising process

The HDGASA is a not-for-profit trade association dedicated to serving the needs of end-users, specifiers, architects, engineers, contractors, fabricators and hot dip galvanizers throughout Southern Africa.

Founded in 1965, the Association's primary objective is to develop and expand the market for hot dip galvanizing and duplex systems as cost effective corrosion control systems.

Hot-dip galvanizing is the process of coating fabricated steel by immersing it into a bath of molten Zn that metallurgically bonds the zinc to the steel to form a tightly bonded alloy coating of high anticorrosive properties (Mass & Peissker, 2011). This practice has been around for over 150 years and provides long-term maintenance-free corrosion protection.

There are three fundamental steps in hot-dip galvanizing: surface 1) preparation, 2) galvanizing and 3) inspection. During step one, the steel goes through three cleaning steps; degreasing, pickling and fluxing. It is pertinent that the steel surface is clean because zinc will not react. During the second step, galvanizing, the steel is dipped into a molten bath that is made up of 99 percent Zn. In the final step, the steel can either be visually inspected to find areas that did not react, or a magnetic thickness gauge can be used to verify if coating thickness meets requirements.

Before the coating is developed through immersion in molten zinc, the steel is cleaned to remove all oils, greases, soils, mill scale, and rust. The cleaning cycle usually consists of a degreasing step, followed by acid pickling to remove scale and rust, and fluxing, which inhibits oxidation of the steel before dipping in the molten zinc.

The two primary elements in hot-dip galvanized steel are Zn and steel, both possessing high recycling rates. The recycled content is determined by weight and then the recycled fraction is multiplied by the cost of the assembly to determine recycle content value. Hot-dip galvanized steel becomes one product when the Zn metallurgically reacts with the iron (Fe), becoming more than 70% combined recycled content.

Hot-dip galvanized steel accounts for 50% of global Zn consumption (Stubbe, *et. al.,* 2016). High prices for Zn, which make up the main part of the cost of galvanizing, require its economical use and disposal of the waste produced – *Zn-Ash* and *Zn-Dross*.

Hot-dip galvanizing isn't something new. It's been around for centuries, and has been proven to protect steel from corrosion, while having minimal environmental, economic or social impacts.

## 1.2 Waste produced

The hot dip galvanizing process generates *Zn-Ash* and *Zn-Dross*, both at present defined as waste in terms of the National Environmental Management Waste Act, Act 59 of 2008, Schedule 3.

i. *Zinc-Ash* is generated from surface oxidation of the galvanizing bath, and
ii. *Zinc-Dross* is a mix of Zn and Fe that accumulates at the bottom of the galvanizing bath.

The amount of dross during galvanizing is around 0.5 to 3.5% of the mass of the treated products. Even though, in terms of its composition, dross mainly consists of ZnO, 30–40% of metallic zinc remains in it. Zinc (Zn) ash represents 12% to 20% of the total amount of Zn used for piece hot galvanizing (Barakat, 2003; Takácová, *et. al.,* 2010; Ainsley, 2019; Konstantinov, *et. al.*, 2015). It is estimated that treatment of one ton of steel generates about 10 kg of *Zn-Dross* and 9 kg of the *Zn-Ash*, giving a potential total Zn stream of 15 - 18 kg to recover.

A process flow chart for the waste generation processes involved and beneficiation to $ZnSO_4$ and ZnO can be viewed in Table 1 and Figure 1.

*Table 1: Process Flow illustration*

| Input | Process flow | Output | Beneficial use (of identified "waste exclusion" products) |
|---|---|---|---|
| | **Step 1**<br>Steel articles received for galvanising | | |
| Hooks and wire | **Step 2**<br>Jigging | | |
| Heat<br>Alkaline degreasing agent<br>Wetting agents<br>Water | **Step 3**<br>Degrease (caustic bath) | Water vapour<br>Spent liquid (Alkaline)<br>Low volume of sludge | |
| Top up water | Water Rinse | | |
| Dilute HCl<br>Water | **Step 4**<br>Acid cleaning (Pickling) | Water vapour<br>Acid fumes<br>Spent Liquid Acid - As a result, iron salts are created, and the acid bath content loses its properties and as a result Spent Pickle Liquor (SPL) is formed | To recycle / regenerate |
| Clean water | Water Rinse | | |
| Water<br>Zinc chloride<br>Ammonium chloride | **Step 5**<br>Stripping for galvanising | Zinc rich spent acid to zinc chemical production | |
| | **Step 6**<br>Flux | Water vapour<br>Filter and regenerate<br>Occasional sludge removal (to waste) - Ferrous hydroxide collects at the bottom of the flux bath | |
| | Drying | | |
| Heat<br>Zinc metal<br>Alloy elements Water | **STEP 7**<br>Hot dip galvanize at 440 - 460°C | Particulate emissions filtered before air emissions to atmosphere<br>Zinc ash and dross to recycling | Zinc ash "recycled" to generate zinc products<br>Zinc Dross "recycled" to generate zinc products |
| | **Step 8**<br>Inspect and despatch | Used wire to steel recycling<br>Hooks to be reused | |

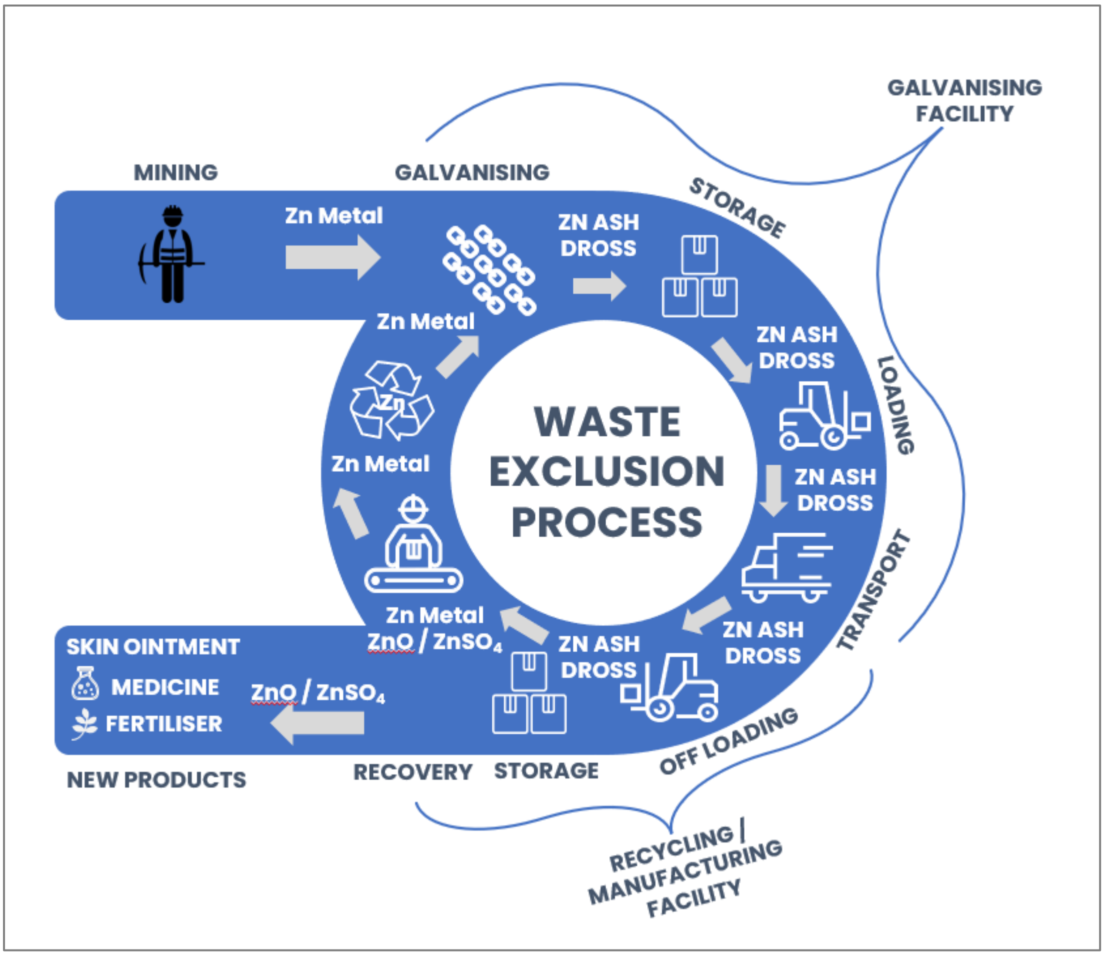

*Figure 1: Galvanising / Recovery / Recycling Process Flow (Products: zinc metal, zinc oxide, zinc sulphate)*

## 2. LEGISLATIVE FRAMEWORK

**Criteria for exclusion of a waste stream or portion of a waste stream from the definition of waste:**

- The Minister may exclude a waste stream or a portion of a waste stream, from the definition of waste for the purposes of beneficial use, provided that the –
  a) application demonstrates that the waste is being or has been or will be used for a beneficial purpose either locally or internationally;
  b) applicant undertakes a risk assessment and submits a risk management plan demonstrating that the intended beneficial use of the excluded waste can be managed in such a way as to ensure that the intended beneficial use will not result in significant adverse impacts on the environment; and
  c) risk management plan developed and responding to the risks identified in the risk assessment undertaken in terms of paragraph (b) above accompanies any delivery of the excluded waste to the user.

**Elements of the Risk Assessment:**

- A risk assessment undertaken in terms of regulation 7(b) must include the following elements:
    - a) provide information that is facility based;
    - b) description and source of the waste;
    - c) intended uses of the excluded waste;
    - d) description of the methodology used to assess the hazardous characteristics of the waste that is to be excluded;
    - e) identification of any potential risks relating to all the activities associated with the intended beneficial use of the excluded waste; and
    - f) identification of mitigation measures that can be used to manage the risks identified in paragraph (e) above.

The results of the risk assessment must be used as the basis of a risk management plan.

**Contents of the Risk Management Plan:**

- The risk management plan contemplated in regulation 7(c) must include the following:
    - a) a Safety Data Sheet ("SDS") which complies with the requirements of SANS 10234, where the waste material is classified as hazardous (refer to Appendix C for safety data sheets);
    - b) permitted uses for which the waste material may be used; and
    - c) a mechanism to record the amount of waste distributed to specific users for a permitted use; including the number of enterprises established or supported and the extent to which previously disadvantaged individuals have been supported.

# 3. OBJECTIVE AND SCOPE OF WORKS

The objective of the project is to apply to the minister of DFFE to exclude *Zn-Ash* and *Zn-Dross* from the definition of "waste" as per the requirements of the GN 715 in GG 41777 of 18 July 2018 Regulations.

The scope of work entailed the following:

1. Risk assessment as per the Legislative Framework, to include:
2. Risk management plan.
3. Waste assessment (GNR635) and waste classification (SANS10234) report inclusive of 1 & 2 above.

The report will be attached as supporting documentation to the application form submitted to the DFFE. The galvanising facilities' locations can be viewed in Appendix A of this report.

## 3.1 SANS 10234 Classification

### 3.1.1 Harmonized criteria for the classification of hazardous substances

Regulations require that waste be classified in terms of SANS 10234, the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). The standard covers the harmonized criteria for the classification of hazardous substances and mixtures, including waste, for their safe transport, use at the workplace or in the home according to their intrinsic health and environmental and physical hazards. It gives the harmonized communication of elements for labelling and for generating Safety Data Sheets (SDS).

The standard accordingly provides detail on classification criteria (hazard classes and categories), labelling, hazard identification symbols (pictograms), packaging and the minimum information required for a 16-point safety data sheet (SDS).

Classification in terms of SANS 10234 means establishing whether a waste is hazardous based on the nature of its intrinsic physical, health and environmental hazardous properties (Hazard Classes), as well as Hazard Categories thereunder, which are subdivisions of each hazard group, indicating the degree or severity of the hazard. The system itself does not consider exposure pathways, but only the intrinsic hazardous properties of the waste.

The SANS10234 covers the harmonised criteria for classification of potentially hazardous substances and mixtures, including wastes, in terms of its properties/hazards. The classification criteria include:

- Physical hazards (flammability, corrosiveness, etc.);
- Health hazards (toxicity, carcinogenicity, etc.); and
- Environmental hazards (aquatic toxicity, bioaccumulation, etc.).

The main aims of the classification in terms of SANS 10234 were to determine:

(a) Whether the waste is hazardous based on the nature of its physical, health and environmental hazardous properties (hazard classes); and
(b) The degree of severity of hazard posed (hazard categories).

The chemical test results as well as intrinsic properties of the waste streams should be used for the SANS 10234 classification. Constituents present in concentrations exceeding 1% are used for classification in terms of health and ecotoxicological hazards, except when the constituent is known to be toxic at lower concentrations (i.e. carcinogens etc.) (Table 2).

*Table 2: Cut-off values/concentration limits for hazard classes*

| Hazard class | Cut-off value (concentration limit) % |
|---|---|
| Acute toxicity | >1.0 |
| Skin corrosion | >1.0 |
| Skin irritation | >1.0 |

| | |
|---|---|
| Serious damage to eyes | >1.0 |
| Eye irritation | >1.0 |
| Respiratory sensitisation | >1.0 |
| Skin sensitisation | >1.0 |
| Mutagenicity:<br>Category 1<br>Category 2 | <br>>0.1<br>>1.0 |
| Carcinogenicity | >0.1 |
| Reproductive toxicity | >0.1 |
| Target organ systemic toxicity | >1.0 |
| Hazardous to the aquatic environment | >1.0 |

### 3.1.2 Carcinogenicity

Classification of a substance as carcinogenic[1] is based on the inherent properties of a substance and does not provide information on the level of the human cancer risk. For the purpose of classification for carcinogenicity, a chemical substance is allocated to one of two categories (Table 3) based on strength of evidence and additional considerations (weight of evidence). In certain instances, route specific classification may be warranted.

*Table 3: Hazard categories for carcinogens*

| Category | Classification criteria |
|---|---|
| 1A | Known to have carcinogenic potential for humans.<br>Based largely on human evidence. |
| 1B | Presumed to have carcinogenic potential for humans:<br>a) evidence from human studies that establish a causal relationship between human exposure to a chemical and the development of cancer (known human carcinogen); or<br>b) evidence from animal tests for which there is sufficient evidence to demonstrate animal carcinogenicity (presumed human carcinogen); and<br>c) on a case-by-case basis, scientific judgement may warrant a decision of presumed human carcinogenicity derived from studies showing limited evidence of carcinogenicity in humans together with limited evidence of carcinogenicity in animal tests. |
| 2 | Suspected human carcinogen:<br>a) evidence obtained from human or animal studies (or both), but which is not sufficiently convincing for classification as a category 1 carcinogen; and<br>b) limited evidence of carcinogenicity in human studies or limited evidence of carcinogenicity in animal tests. |

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[1] Chemical substance or a mixture of chemical substances which induce cancer or increase its incidence when inhaled, ingested or absorbed through the skin which the use of the substance may present.

### 3.1.3 Toxicity Test Classification System

Acute (and short-chronic) toxicity testing was applied by exposing biota to the ash leachate to determine the potential risk of potential leachate to the biota/biological integrity of the receiving water bodies. A risk category was determined based on the percentage of mortalities (or inhibition-stimulation) of the exposed biota.

It is important to note that the hazard classification is based on the standardised battery of selected test biota and therefore represents the risk/hazard towards similar biota in the receiving aquatic environment. The toxicity hazard is therefore in terms of the aquatic biotic integrity and does in no way represent toxicology towards humans or other mammals.

Standard, internationally accepted methods and materials were applied to conduct acute and chronic toxicity tests and hazard classification, based on 3 trophic levels (3 taxonomic groups). Four aquatic test species (*Daphnia magna*, *Spirodela polyrhiza* and *Poecilia reticulata*) were exposed to the leachate (1:10) to determine acute toxic effects.

A risk/hazard category was determined by application of the DEEEP (*Direct Estimation of Ecological Effect Potential*) protocol as recommended by the DWS. This risk category equates to the level of acute/chronic risk posed by the selected potential pollution source (leachate). The acute risk relates to the mortality rate while the chronic risk relates to the growth inhibition of the exposed biota.

After the determination of the percentage effect (EP), obtained with each of the battery of toxicity tests performed, the samples were ranked into one of the following five classes (classified according to the highest toxicity unit found in the battery of toxicity definitive tests performed) in Table 4.

*Table 4: Toxicity classification system*

| | |
|---|---|
| Class I | No acute/chronic hazard – none of the tests shows a toxic effect |
| Class II | Slight acute/chronic hazard – the percentage effect observed in at least one toxicity test is significantly higher than in the control, but the effect level is below 50% (TU is <1). |
| Class III | Acute/chronic hazard – the L(E)C50 is reached or exceeded in at least one test, but in the 10-fold dilution of the sample the effect level is below 50% (TU is between 1 and 10). |
| Class IV | High acute/chronic hazard – the L(E)C50 is reached in the 10-fold dilution for at least one test, but not in the 100-fold dilution (TU is between 10 and 100). |
| Class V | Very high acute/chronic hazard – the L(E)C50 is reached in the 100-fold dilution for at least one test (TU is >100). |

Each sample was furthermore weighted per its relative toxicity levels (out of 100%). Higher values indicate that more of the individual tests indicated toxicity within a specific class.

## 3.2 Phase 2: High-level human health and ecological risk assessment

Phase 2 of the project involved data interpretation and quantification in terms of the potential risks towards:

- human health;
- environmental health (surface and groundwater); and
- aquatic health.

Other impact assessments that were qualified as per the Regulations included visual and socio-economic aspects related to the project.

The risk assessment paradigm essentially consisted of the following logical steps:

- A hazard assessment identified the chemical contaminants suspected to pose hazards and a description of the types of toxicity that they may evoke;
- An Exposure assessment included a description of the environmental pathways and distribution of hazardous substances and identification of receptors; and
- Risk characterisation, involving the integration of the components described above to determine whether specific exposures to an individual, community or towards the environment might lead to adverse health effects.

## 3.3 Assessment of Waste for Disposal to Landfill in terms of GNR 635 of 23 August 2013 (NEM:WA)

The NEM:WA defines waste as:

- general waste, which does not pose an immediate hazard or threat to health or to the environment; and
- hazardous waste, which is any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment.

The DEA National Norms and Standards for the Assessment of Waste for Landfill Disposal, General Notice No. 635 (Government Gazette No. 36784, 23 August 2013) under the National Environmental Management Waste Act 59 of 2008 (NEMWA) was used to assess the waste stream. Note that the GNR635 only applies to waste that will be disposed indefinitely. If it is recovered, recycled or re-used, the GNR 635 does not apply. In some cases, therefore, the guidelines are used for reference purposes only.

According to the Standards, the assessment methodology to determine the specific type of waste for disposal to landfill, is by comparing the Total Concentrations (TC) and Leachable Concentrations (LC) of the waste material to the prescribed threshold limits. Exceedances of the threshold limits determine the type of waste (Type 0 to Type 4 Wastes).

The following analyses were performed to assess the waste type:

Inorganic assays

- Acid digestion and analyses of aliquot to determine total inorganic content that included trace and major metals.
- Leachate test followed by ICP scan for leachable inorganic content, including pH, TDS and selected anions.
    - A solid to liquid ratio of 1:20 was used for all leachate analyses.

The criteria below were used to determine the risk for contaminant release (Table 5).

*Table 5: Description of risk associated with disposal to land*

| **Criteria** | **Waste Disposal Risk Rating** | **Description of Risk associated with disposal to land** |
|---|---|---|
| LC > LCT3, or TC > TCT2 | Type 0: Very High Risk | Considered very high-risk waste with a very high potential for contaminant release. Requires very high level of control and ongoing management to protect health and environment. |
| LCT2 < LC ≤ LCT3, or TCT1 < TC ≥ TCT2 | Type 1: High Risk | Considered high risk waste with a very high potential for contaminant release. Requires very high level of control and ongoing management to protect health and environment. |
| LCT1 < LC ≤ LCT2 and TC ≤ TCT1 | Type 2: Moderate Risk | Considered moderate risk waste with some potential for contaminant release. Requires proper control and ongoing management to protect health and the environment. |
| LCT0 < LC ≤ LCT1 and TC ≤ TCT1 | Type 3: Low Risk | Low risk waste with low potential for contaminant release. Requires some level of control and ongoing management to protect health and the environment. |
| TC < 20 x LCT1, or LC ≤ LCT1 and TC ≤ TCT1 | Type 4: Inert Waste | Very low risk waste that-<br>(a) Does not undergo any significant physical, chemical or biological transformation;<br>(b) does not burn, react physically or chemically or otherwise affect any matter with which it may come into contact; and<br>(c) does not impact negatively on the environment because of its very low pollutant content and because the toxicity of its leachate is insignificant.<br>Only basic control and management required. |

## 4. Results and Discussion

The main aims of the tests were to characterise and classify the *Zn-Ash* and *Zn-Dross* in terms of its i) potential physical, human and environmental hazards (SANS 10234); ii) providing a high-level human health and ecological risk assessment; and iii) hazard classification towards natural receiving surface water bodies.

The following tests were performed:

1. Mineralogical composition by X-ray diffraction (XRD).
2. Total minor and major elemental composition test by acid digestion and ICP analysis.
3. Distilled water leach test to determine the leachable fraction of the chemical components or bioavailability.
4. Definitive toxicity tests on aquatic indicator test organisms.

Samples for *Zn-Dross* and *Zn-Ash* were received from the client and submitted to UIS Analytical Laboratory (accreditation No. T0184) and Biotox Lab (accreditation No. T0663) for geochemistry analyses and toxicity assays. * Note that samples from the respective galvanising facilities were composited and the results are there representative of averaged data for all the facilities included in the exclusion aaplication.

The geochemical investigation was performed to identify contaminants of concern (“CoC”) and specific elements that will pose an environmental and leachate risk. Crystalline mineralogical abundances including whole rock elemental analyses (aqua regia) and a leachate assessment (1:20 solid:distilled water) were performed. The toxicity assays were performed following the Direct Estimation of Ecological Effect Potential (“DEEEP”) to determine the hazard response of certain indicator organisms to leachate generation should it come into contact with natural surface water resources.

A GNR635 Waste Assessment and SANS10234 Waste Classification were also performed as supporting documentation to the application.

The samples received were prepared to represent the best- and worst-case scenarios regarding the chemical content. The samples were composited into one sample to represent an average for all the processes involved.

## 4.1 Mineralogical composition

Table 6 below tabulates the mineralogical abundance ratios of the *Zn-Ash* and *Zn-Dross* by-products from the galvanising process.

Zinc (Zn) or Zn compounds are the main components of the ash and dross. The ash contains 74.7% elemental zinc and 16.95 ZnO with minor copper (Cu) as botallackite-(Zn), a secondary copper mineral. Some minor Zn-Fe is present in the dross sample a content of 43.3%.

*Table 6: Mineral abundance of the waste material produced*

| Description | Chemical formula | unit | Zn Ash | Zn Dross |
|---|---|---|---|---|
| Zinc | Zn | % | 74.72 | 56.66 |
| Zincite (ZnO) | ZnO | % | 16.95 | |
| Botallackite-(Zn) | $CuZnCl(OH)3$ | % | 8.34 | |

| Description | Chemical formula | unit | Zn Ash | Zn Dross |
|---|---|---|---|---|
| Zn-iron | Zn-Fe | | | 43.34 |
| **Total** | | | **100.01** | **100** |

## 4.2 Whole elemental analysis

Trace and major elemental compositions were determined by digesting a representative sample of the materials with *aqua reqia* and analysing the supernatant with ICP. The results of the whole elemental analyses, evaluated according to the Total Concentration Thresholds (TCTs) as per the GNR635 National Norms and Standards, are displayed n Figure 2 and Table 7 below.

It is clear from the data that the ash and dross are predominantly composed of Zn with minor Cu, Ni, Pb, Fe and/or Mn.

The significance of these limits is not directly related to the degree of toxicity that may result after exposure long- or short term but merely signifies a “potential risk”. Metal species that are more soluble are considered more bioavailable and toxic. Of all the factors that can influence the speciation of metals in water (or leachate) include: (1) ionic strength of the medium, (2) hardness of the water, (3) presence of organic matter, (4) pH, (5) redox potential and (6) its valence state. In this case, pH is possibly the most important factor that will determine bioavailability and toxicity. Therefore, with reference to the ‘total’ threshold limits of the GNR635, these were established to “classify” waste materials with reference to their potential environmental risk.

It must be stressed that the exceedances of these elements imply that only potential environmental risks or hazards are associated with the materials, since only the bioavailable fractions are potentially hazardous to the environment. Where the whole rock analyses become relevant is with regards to human health evaluations since constituents present in concentrations exceeding 1% are used for classification in terms of health hazards (refer to Table 1).

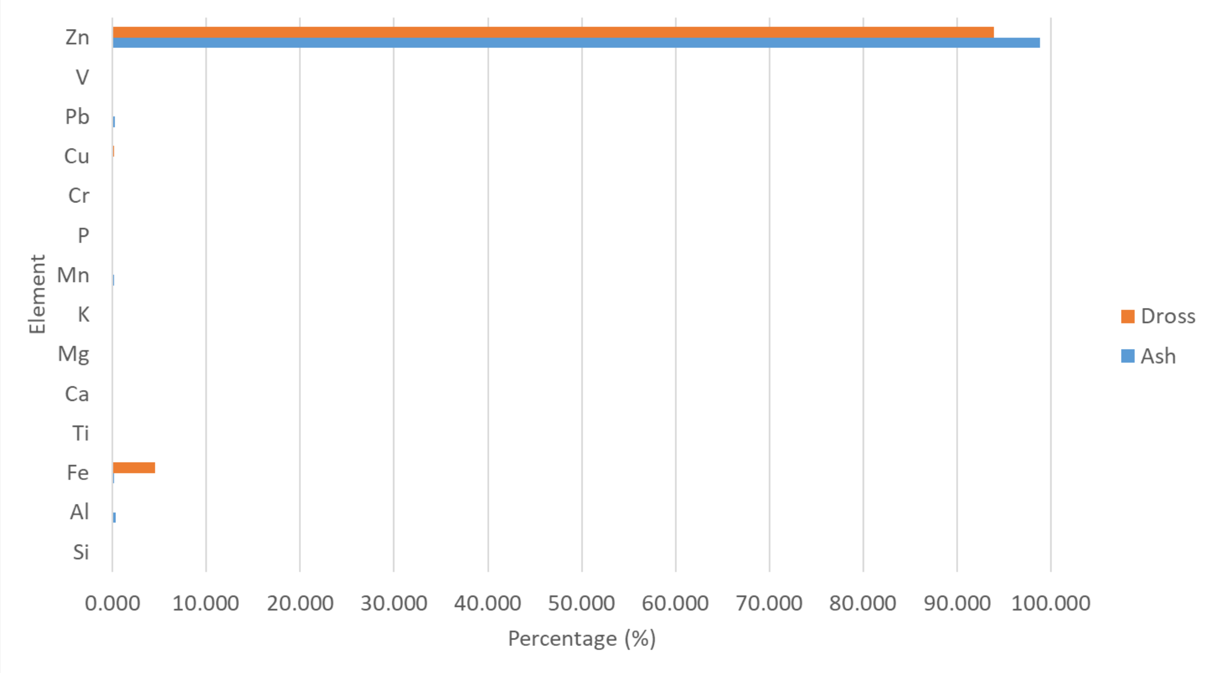

*Figure 2: Major elements, loss on material on ignition (LoI) and moisture content (whole rock elemental analysis)*

*Table 7: Total trace elemental results (in mg/kg) compared against the Total Concentration Threshold (TCT) Limits of GNR635*

| **Elements & Chemical Substances** | **Ash** | **Dross** | **TCT0** | **TCT1** |
|---|---|---|---|---|
| Ag, silver (mg/kg) | 3.91 | 5.47 | n/a | n/a |
| As, arsenic (mg/kg) | **45.9** | 2.31 | 5.8 | 500 |
| Ba, barium (mg/kg) | 1.17 | 8.30 | 62.5 | 6250 |
| Be, beryllium (mg/kg) | <0.10 | 0.14 | n/a | n/a |
| Bi, bismuth (mg/kg) | 0.93 | 0.29 | n/a | n/a |
| Cd, cadmium (mg/kg) | 3.95 | 2.19 | 7.5 | 260 |
| Co, cobalt (mg/kg) | 0.55 | 29.1 | 50 | 5000 |
| Cr, chromium (mg/kg) | 41.0 | 142 | 46000 | 800000 |
| Cs, caesium (mg/kg) | <0.10 | 0.24 | n/a | n/a |
| Cu, copper (mg/kg) | **44.8** | **2020** | 16 | 19500 |
| Fe, iron (mg/kg) | 1939 | 45300 | na | na |
| Ga, gallium (mg/kg) | 2.22 | 1.92 | n/a | n/a |
| Ge, germanium (mg/kg) | 1.12 | 1.34 | n/a | n/a |
| Hg, mercury (mg/kg) | <0.10 | 0.12 | 0.93 | 160 |
| Ho, holmium (mg/kg) | <0.10 | <0.10 | n/a | n/a |
| In, Indium (mg/kg) | <0.10 | <0.10 | n/a | n/a |
| Mn, manganese (mg/kg) | **1186** | 332 | 1000 | 25000 |

| Elements & Chemical Substances | Ash | Dross | TCT0 | TCT1 |
|---|---|---|---|---|
| Mo, molybdenum (mg/kg) | 3.88 | 6.99 | 40 | 1000 |
| Nb, niobium (mg/kg) | 17.4 | 2.09 | n/a | n/a |
| Ni, nickel (mg/kg) | **401** | **10165** | 91 | 10600 |
| Pb, lead (mg/kg) | **2249** | **494** | 20 | 1900 |
| Sb, antimony (mg/kg) | 5.18 | 3.47 | 10 | 75 |
| Sc, scandium (mg/kg) | 0.18 | 0.23 | n/a | n/a |
| Se, selenium (mg/kg) | 2.37 | 2.33 | 10 | 50 |
| Sn, tin (mg/kg) | 44.7 | 370 | n/a | n/a |
| Sr, strontium (mg/kg) | 0.49 | 1.42 | n/a | n/a |
| Ta, tantalum (mg/kg) | <0.10 | <0.10 | n/a | n/a |
| Te, tellurium (mg/kg) | <0.10 | <0.10 | n/a | n/a |
| Th, thorium (mg/kg) | <0.10 | <0.10 | n/a | n/a |
| Tl, thallium (mg/kg) | 10.8 | 0.14 | n/a | n/a |
| U, uranium (mg/kg) | <0.10 | <0.10 | n/a | n/a |
| V, vanadium (mg/kg) | 28.0 | 11.3 | 150 | 2680 |
| W, tungsten (mg/kg) | 0.28 | 0.44 | n/a | n/a |
| Zr, zirconium (mg/kg) | 5.34 | 4.88 | n/a | n/a |
| Zn, zinc (mg/kg) | **988 206** | **939 228** | 240 | 160000 |

* Bold and coloured text exceed corresponding colour coded TCT value

na not available

## 4.3 Leachable concentrations

The results of the leachate assessment are shown in Table 8. The results, evaluated according to the GNR635 LCT limits, show relatively low mineralisation of trace elements except for Zn and Mn in the ash sample, which recorded a concentration of 2264 mg/l and 45.42 mg/l, respectively. TDS was also recorded as relatively raised with a concentration of 5182 mg/l in the *Ash*. The raised TDS is caused by chloride (Cl), which was recorded as 2906 mg/l in the ash. All major and trace metals were recorded as low to undetected in the *Dross* sample.

*Table 8: Leachable inorganic concentration results evaluated according to the Leachable Concentration Threshold (LCT) Limits*

| Elements & Chemical Substances | Ash | Dross | LCT0 | LCT1 |
|---|---|---|---|---|
| pH | 6.36 | 8.07 | n/a | n/a |
| TDS (mg/l) | **5182** | <30 | 1000 | 12500 |
| EC (mS/m) | 842 | 1 | n/a | n/a |

| Elements & Chemical Substances | Ash | Dross | LCT0 | LCT1 |
|---|---|---|---|---|
| P Alk, carbonate alkalinity (mg/l $CaCO_3$)[2] | <0.6 | <0.6 | n/a | n/a |
| M Alk, total alkalinity (mg/l $CaCO_3$)[3] | 32.5 | 5.50 | n/a | n/a |
| F, fluoride (mg/l) | 0.96 | <0.1 | 100 | 10000 |
| Cl, chloride (mg/l) | 2906 | <0.25 | 300 | 15000 |
| $NO_3$, nitrate (mg N/l) | <0.1 | <0.1 | 11 | 550 |
| $PO_4$, phosphate (mg P/l) | <0.8 | <0.8 | n/a | n/a |
| $SO_4$, sulphate (mg/l) | 1.07 | <0.3 | 250 | 12500 |
| Ag, silver (mg/l) | 0.001 | <0.001 | n/a | n/a |
| Al, aluminium (mg/l) | <0.01 | <0.01 | n/a | n/a |
| As, arsenic (mg/l) | 0.001 | <0.001 | 0.01 | 0.5 |
| Au, gold (mg/l) | <0.001 | <0.001 | n/a | n/a |
| B, boron (mg/l) | 0.061 | <0.001 | 0.5 | 25 |
| Ba, barium (mg/l) | 0.285 | 0.014 | 0.7 | 35 |
| Be, beryllium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Bi, bismuth (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Ca, calcium (mg/l) | 9.567 | 1.221 | n/a | n/a |
| Cd, cadmium (mg/l) | <0.001 | <0.001 | 0.003 | 0.15 |
| Ce, cerium (mg/l) | 0.018 | <0.001 | n/a | n/a |
| Co, cobalt (mg/l) | 0.003 | <0.001 | 0.5 | 25 |
| Cr, chromium (mg/l) | <0.001 | <0.001 | 0.1 | 5 |
| Cs, caesium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Cu, copper (mg/l) | 0.093 | 0.001 | 2.0 | 100 |
| Fe, iron (mg/l) | 0.390 | <0.01 | n/a | n/a |
| Ga, gallium (mg/l) | 0.016 | <0.001 | n/a | n/a |
| Ge, germanium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Hf, hafnium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Hg, mercury (mg/l) | <0.001 | <0.001 | 0.006 | 0.3 |
| Ho, holmium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Ir, iridium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| K, potassium (mg/l) | 19.634 | 0.185 | n/a | n/a |
| La, lanthanum (mg/l) | 0.009 | <0.001 | n/a | n/a |
| Li, lithium (mg/l) | 0.003 | <0.001 | n/a | n/a |
| Mg, magnesium (mg/l) | 0.799 | 0.040 | n/a | n/a |
| Mn, manganese (mg/l) | 45.42 | 0.012 | 0.5 | 25 |

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[2] The P-alkalinity is a measure of the amount of acid required to drop the pH to approximately 8.3. This measure the amount of any carbonate or hydroxide alkalinity present.

[3] The M-alkalinity is a measure of the amount of acid it takes to drop the pH to approximately 4.3. This directly measure the amount of any bicarbonate, carbonate, and hydroxide alkalinity present, depending upon the starting pH.

| Elements & Chemical Substances | Ash | Dross | LCT0 | LCT1 |
|---|---|---|---|---|
| Mo, molybdenum (mg/l) | 0.025 | <0.001 | 0.07 | 3.5 |
| Na, sodium (mg/l) | 27.104 | 0.465 | n/a | n/a |
| Nb, niobium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Nd, neodymium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Ni, nickel (mg/l) | 0.258 | 0.002 | 0.07 | 3.5 |
| Pb, lead (mg/l) | 0.123 | <0.001 | 0.01 | 0.5 |
| Pt, platinum (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Rb, rubidium (mg/l) | 0.007 | <0.001 | n/a | n/a |
| Sb, antimony (mg/l) | <0.001 | <0.001 | 0.02 | 1 |
| Sc, scandium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Se, selenium (mg/l) | 0.004 | 0.003 | 0.01 | 0.5 |
| Si, silicon (mg/l) | <0.01 | <0.01 | n/a | n/a |
| Sn, tin (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Sr, strontium (mg/l) | 0.038 | 0.004 | n/a | n/a |
| Ta, tantalum (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Te, tellurium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Th, thorium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Ti, titanium (mg/l) | <0.01 | <0.01 | n/a | n/a |
| Tl, thallium (mg/l) | 0.007 | <0.001 | n/a | n/a |
| U, uranium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| V, vanadium (mg/l) | 0.004 | 0.003 | 0.2 | 10 |
| W, tungsten (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Y, yttrium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| Zn, zinc (mg/l) | 2246 | 0.056 | 5 | 250 |
| Zr, zirconium (mg/l) | <0.001 | <0.001 | n/a | n/a |
| $Cr^{6+}$, hexavalent chromium (mg/l) | <0.05 | <0.05 | 6.5 | 500 |

## 4.4 Environmental toxicity assays

The primary objective for the classification of substances and mixtures as hazardous to the aquatic environment in terms of the SANS 10234 guidelines is to alert the user to the hazards these substances and mixtures present to ecosystems. The present criteria refer by and large to aquatic ecosystems; however certain substances and mixtures simultaneously, or alternatively can affect other ecosystems that include soil microflora (SANS10234, 2008).

The test protocol consists of a battery of tests to directly assess lethal (acute) and sub-lethal (chronic) toxicity, using test organisms from a range of trophic levels. These toxicity tests can demonstrate whether contaminants are bioavailable, it can evaluate the aggregate toxic effects of all contaminants in the medium and it can evaluate the toxicity of substances whose biological effects may not have been well characterized.

Lethal or sub-lethal toxicity testing (as applied for this assessment) is applied by exposing biota to the leachate of the samples submitted in order to determine the potential risk of such leachates to the biota/biological integrity of the receiving water bodies and the environment. A risk category is determined based on the percentage of mortalities (lethal) or inhibition (sub-lethal) of the exposed biota. It is important to note that the hazard classification is based on the standardised battery of selected test biota and therefore represents the risk/hazard towards similar biota in the receiving aquatic environment. The toxicity hazard is therefore in terms of the aquatic biotic integrity and does in no way represent toxicology towards humans or other mammals.

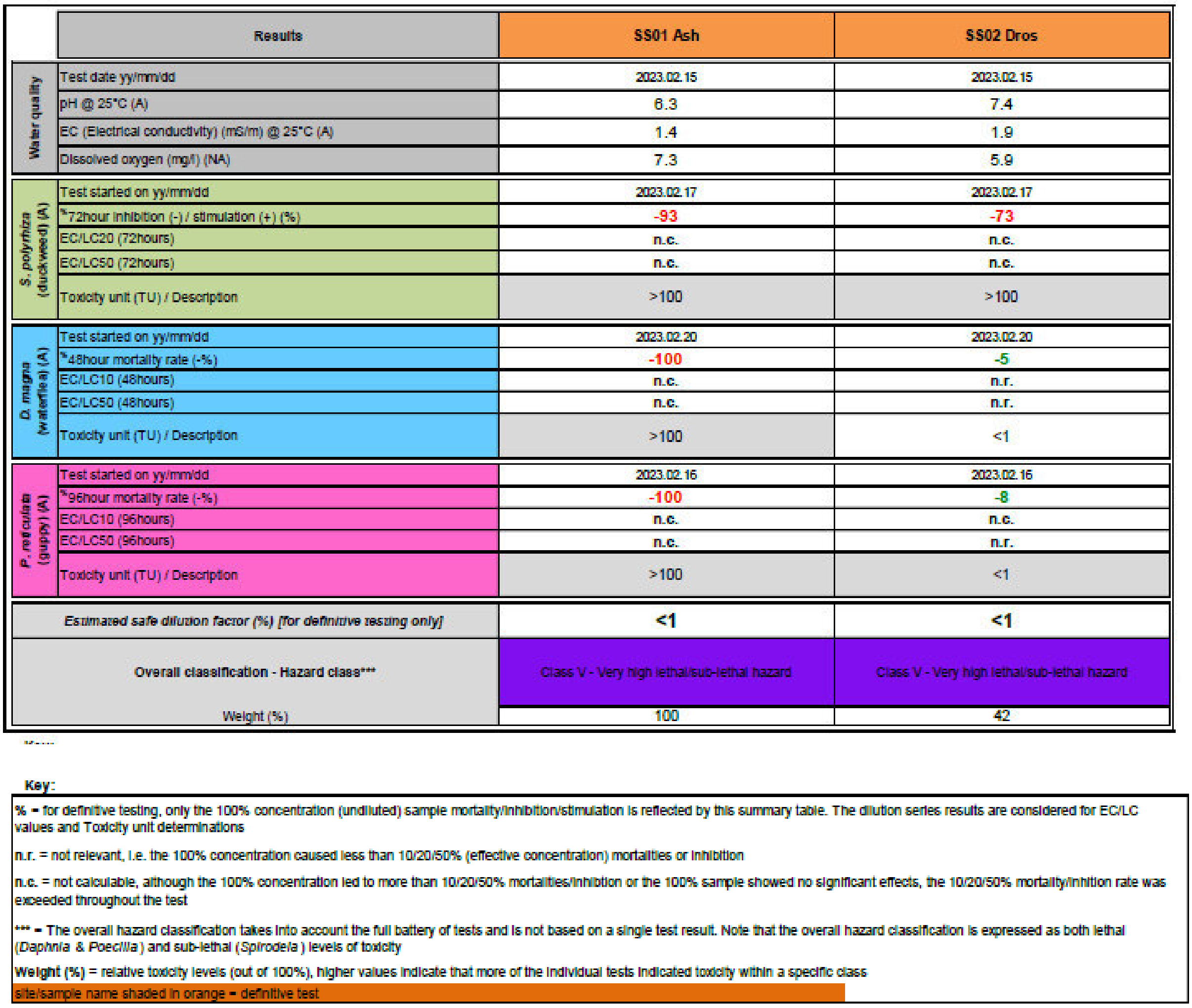
The samples were leached and exposed to 3 trophic levels of test aquatic organisms (*Spirodela polyrhiza*, *Daphnia magna* and *Poecilia reticulata*). The samples were leached following a standard leachate procedure and ratio of 1:10.

The results of the assays and the final hazard classification are displayed in Table 9.

The leachate pH levels of the ash and dross were recorded as 6.3 and 7.4, respectively, which are within the acceptable range (pH 6-9) in which pH can be excluded as a driving factor for toxicity (USEPA, 1996). The conductivities (ECs) of the leachate samples were 1.4 mS/m (*SS01-Ash*) and 1.9 mS/m (*SS02-Dross*).

Both samples were allocated a Hazard Class V (very high lethal/sub-lethal environmental toxicity hazard). For sample SS01 Ash, the 50% effect level was exceeded throughout the test on all 3 trophic levels applied during testing. For sample SS02 (*Dross*), the 50% effect level was exceeded throughout the duckweed (*S. polyrhiza*) test (sub-lethal) and although no significant effect was noted following the vertebrate (*P. reticulata*) test, slight mortalities were noted on the lowest dilution of the leachate sample (1% dilution).

Table 9: Hazard classification of the leachate sample



| | Results | SS01 Ash | SS02 Dros |
|---|---|---|---|
| Water quality | Test date yy/mm/dd | 2023.02.15 | 2023.02.15 |
| | pH @ 25°C (A) | 6.3 | 7.4 |
| | EC (Electrical conductivity) (mS/m) @ 25°C (A) | 1.4 | 1.9 |
| | Dissolved oxygen (mg/l) (NA) | 7.3 | 5.9 |
| *S. polyrhiza* (duckweed) (A) | Test started on yy/mm/dd | 2023.02.17 | 2023.02.17 |
| | %72hour inhibition (-) / stimulation (+) (%) | -93 | -73 |
| | EC/LC20 (72hours) | n.c. | n.c. |
| | EC/LC50 (72hours) | n.c. | n.c. |
| | Toxicity unit (TU) / Description | >100 | >100 |
| *D. magna* (waterflea) (A) | Test started on yy/mm/dd | 2023.02.20 | 2023.02.20 |
| | %48hour mortality rate (-%) | -100 | -5 |
| | EC/LC10 (48hours) | n.c. | n.r. |
| | EC/LC50 (48hours) | n.c. | n.r. |
| | Toxicity unit (TU) / Description | >100 | <1 |
| *P. reticulata* (guppy) (A) | Test started on yy/mm/dd | 2023.02.16 | 2023.02.16 |
| | %96hour mortality rate (-%) | -100 | -8 |
| | EC/LC10 (96hours) | n.c. | n.c. |
| | EC/LC50 (96hours) | n.c. | n.r. |
| | Toxicity unit (TU) / Description | >100 | <1 |
| *Estimated safe dilution factor (%) [for definitive testing only]* | | **<1** | **<1** |
| Overall classification - Hazard class*** | | Class V - Very high lethal/sub-lethal hazard | Class V - Very high lethal/sub-lethal hazard |
| Weight (%) | | 100 | 42 |

**Key:**

% = for definitive testing, only the 100% concentration (undiluted) sample mortality/inhibition/stimulation is reflected by this summary table. The dilution series results are considered for EC/LC values and Toxicity unit determinations

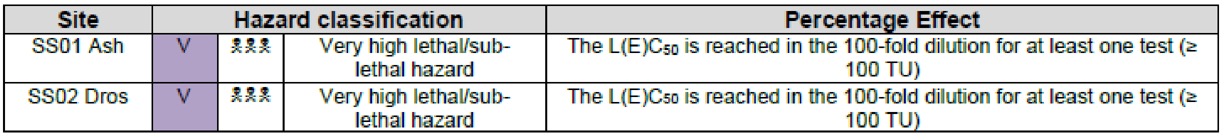
n.r. = not relevant, i.e. the 100% concentration caused less than 10/20/50% (effective concentration) mortalities or inhibition

n.c. = not calculable, although the 100% concentration led to more than 10/20/50% mortalities/inhibtion or the 100% sample showed no significant effects, the 10/20/50% mortality/inhition rate was exceeded throughout the test

*** = The overall hazard classification takes into account the full battery of tests and is not based on a single test result. Note that the overall hazard classification is expressed as both lethal (*Daphnia* & *Poecilia*) and sub-lethal (*Spirodela*) levels of toxicity

**Weight (%)** = relative toxicity levels (out of 100%), higher values indicate that more of the individual tests indicated toxicity within a specific class

site/sample name shaded in orange = definitive test



| Site | Hazard classification | | | Percentage Effect |
|---|---|---|---|---|
| SS01 Ash | V | ☠☠☠ | Very high lethal/sub-lethal hazard | The L(E)$C_{50}$ is reached in the 100-fold dilution for at least one test (≥ 100 TU) |
| SS02 Dros | V | ☠☠☠ | Very high lethal/sub-lethal hazard | The L(E)$C_{50}$ is reached in the 100-fold dilution for at least one test (≥ 100 TU) |

## 4.5 SANS 10234 CLASSIFICATION

Chemical substances are allocated to one of five acute toxicity hazard categories based on acute toxicity by the oral, dermal or inhalation route in accordance with the numeric cut-off values as shown in Table 10.

Table 10: Acute toxicity hazard categories and acute toxicity estimate (ATE) values

| Routes of exposure | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 |
|---|---|---|---|---|---|
| **Oral** ($LD_{50}$ expressed as mg/kg bodyweight) | 5 | 50 | 300 | 2000 | 5000 |
| **Dermal** ($LD_{50}$ expressed as mg/kg bodyweight | 50 | 200 | 1000 | 2000 | |

Acute toxicity values are expressed as (approximate) LD50 (oral, dermal) or LC50 (inhalation) values or as acute toxicity estimates (ATE). The calculation approach for combined acute toxicity estimates for mixtures/ingredients is by making use of a weighting summation procedure taking ATE values and the concentrations of the relevant 'ingredients' into account. The combined ATE is calculated with the following formula:

$$\frac{100}{ATEmix} = \sum_{n=1}^{\infty}\left(\frac{Ci}{ATEi}\right)$$

| | | |
|---|---|---|
| ATE | = | Acute Toxicity Estimate (e.g. LD50 / LC50) |
| Ci | = | Concentration of ingredient i |
| I | = | Individual Relevant ingredient from 1 to n |
| N | = | Number of ingredients |

The material analysed during the current assessment are classified below in terms of SANS 10234.

For the *Zn-Ash* only Zn recorded above the 1% cut-off value while for the *Zn-Dross*, Zn, Fe and Ni exceeded the cut-off value.

The following acute toxicity data as in Table 11 is available for Zn, Fe and Ni. *Note that, based on the SANS10234 Regulations, an 'ingredient' can be ignored if the data does not show an acute toxicity at >2 000 mg/kg bodyweight.*

*Table 11: Relevant acute toxicity data (RTECS)*

| Type of test | Route of exposure | Species | Does data | Toxic effects |
|---|---|---|---|---|
| **Acute Toxicity Data for Zinc; Cas 7440-66-6** | | | | |
| $LD_{50}$ | Oral | Rodent/mouse | 5000 mg/kg/day | Liver - other changes, Kidney/Ureter /Bladder – changes primarily in glomeruli Biochemical – Enzyme inhibition, induction, or change in blood or tissue levels - multiple enzyme effects (RTECS for Zn, TTECS Number ZG8600000). |
| $LD_{50}$ | Dermal | Minks | - | No dermal effects were seen in adult female minks given a time-weighted dose of 20.8 mg zinc/kg/day as zinc sulphate for 10 weeks prior to mating and then throughout gestation and lactation (Bleavins et al. 1983). However, the offspring of these animals showed greying of the fur around the eyes, ears, jaws, and genitals with a concomitant loss of hair and dermatosis in these areas during the weaning period. These conditions were reversible upon removal of treatment. |

| Type of test | Route of exposure | Species | Does data | Toxic effects |
|---|---|---|---|---|
| $LD_{50}$ | Inhalation | Unknown | - | No inhalation MRLs were derived for zinc (ATSDR, 2005). |
| **Acute Toxicity Data for Iron; Cas 7439-89-6** | | | | |
| $TDL_0$ | Oral | Human - child | 44 mg/kg | Behavioural irritability, Gastrointestinal-nausea or vomiting, Blood- Normocytic anaemia |
| $LD_{50}$ | Oral | Human | 200 mg/kg | Vascular- Shock, Liver- Hepatitis, Diffuse nutritional and Gross Metabolic acidosis |
| $TCL_0$ | Inhalation | Rodent - rat | 250 $mg/m^3$/6H/4W (intermittent) | Lungs, thorax or, Respiration- chronic pulmonary enema |
| $TDL_0$ | Subcutaneous | Mouse | 41.4 mg/kg/2W (Intermittent) | Reproductive- Spermatogenesis of genetic material, sperm morphology, motility and count |
| $LD_{50}$ | Oral | Rodent-rat | 750 mg/kg – lethal oral dose, 50% kill | Blood – changes in serum composition (e.g. TP, bilirubin, cholesterol) Biochemical - Enzymeinhibition, induction, or change in blood or tissue levels – transaminases. |
| **Acute Toxicity Data for Nickel; Cas 7440-02-0** | | | | |
| $LD_{50}$ | Oral | Rodent-rat | 39 – 136 mg/kg | Oral LD50 values of 46 or 39 mg Ni/kg as nickel sulphate in male and female rats (Mastromatteo 1986) and 116 and 136 mg Ni/kg as nickel acetate in female rats and male mice, respectively (Haro et al. 1968) have been reported for soluble nickel compounds. In contrast, the oral LD50 values in rats for less-soluble nickel oxide and subsulphide were >3930 and >3665 mg Ni/kg, respectively (Mastromatteo 1986). |
| - | Dermal | - | - | No studies were located regarding dermal effects in humans following exposure. However, contact dermatitis in persons exposed to nickel compounds is one of the most common effects of nickel exposure. In addition, immunological studies indicate that the dermatitis is an allergic response to nickel, and significant effects on the immune system have been noted in workers exposed to nickel. |
| MRL | Inhalation | Human | 0.0002 mg $Ni/m^3$ | Soluble nickel compounds may not be directly carcinogenic, as indicated by the negative |

| Type of test | Route of exposure | Species | Does data | Toxic effects |
|---|---|---|---|---|
| | | | | results in the nickel sulphate bioassay, inhalation of nickel sulphate did result in an inflammatory response in the lungs of animals. Because sustained tissue damage can serve to promote carcinogenesis, epidemiology studies of humans who are exposed to many substances may not be able to distinguish between the carcinogenic activity of less-soluble nickel compounds and the promoting activity of toxic concentrations of soluble nickel compounds.<br>The Department of Health and Human Services of the USA has determined that metallic nickel may reasonably be anticipated to be a human carcinogen and nickel compounds are known to be human carcinogens.<br>Similarly, IARC classified metallic nickel in group 2B (possibly carcinogenic to humans) and nickel compounds in group 1 (carcinogenic to humans). EPA has classified nickel refinery dust and nickel subsulphide in Group A (human carcinogen). |

TDL0 - Lowest toxic dose
LD50 - Lethal dose (LD50) - the amount of an ingested substance that kills 50% of a test sample
TCL0 - Lowest concentration capable of producing a defined toxic effect
MRL – Minimum risk level

Table 12 below highlights the main findings of the classification and characterisation.

*Table 12: Geochemical characterisation and classification summary*

| **Unit** | **Whole rock analyses** | **Mineralogy** | **Leachability** | **Risks or hazards** | | | |
|---|---|---|---|---|---|---|---|
| | | | | **Physical** | **Environmental** | **Human** | **Aquatic/biological** |
| Zn-ash | Composed of Zn substances only. | Predominantly elemental Zn, ZnO and a Zn-Cu-Cl mineral (Botallackite) | TDS leached in raised levels with Cl as major contributor owing to the botallackite mineral. Minor leachability of major ions but Fe and Zn leached in substantial levels. | In the presence of moisture, Zn-ash may ignite spontaneously on contact with air; reacts violently with oxidants and powdered sulphur, causing fire and explosion hazards. (Handling Chemicals Safely 1980. p. 966). | The risk of pollution posed to the natural receiving environment is high due to high mobility and dissolution of Cl and Mn into solution. | Based on the SANAS 10234 classification conducted, Zn-ash is a *<u>Category 5</u>* - Low Acute Toxicity. | Very high lethal/sub-lethal hazard but low risk based on low exposure and absence of defined pathways and receptors (subjected to appropriate management measures implemented). |
| Zn-dross | Composed of Zn substances only. | Predominantly elemental Zn but also Zn-Fe. | Minor mobility of major non-hazardous cations (Ca, Mg, Na) but leachability of potentially toxic metals are low. | Zn Dross is non-flammable, non-combustible and stable under normal storage and handling conditions | The risk of pollution posed to the natural receiving environment is low due to the low leachable levels of potential toxic metals. | Based on the SANAS 10234 classification conducted, Zn-ash is a *<u>Category 4</u>* Oral Hazard and is considered harmful if swallowed. | Very high lethal/sub-lethal hazard but low risk based on low exposure and absence of defined pathways and receptors (subjected to appropriate management measures implemented). |

## 4.6 GNR 635 WASTE ASSESSMENT

The data as generated through this investigation was also used to assess the ash in regard to the GNR 635 Norms and Standards for waste disposal to landfill.

Based on the results as presented in Section 4, the ***Zn-ash*** is assessed to be a ***Type 0*** waste material due to soluble Zn exceeding LCT3 limits as per the Norms and Standards [7(2)(a)] –

- *Wastes with any element or chemical substance concentration above the LCT3 or TCT2 limits (LC > LCT3 or TC > TCT2) are Type 0 Wastes.*

Based on the results as presented in Section 4, the ***Zn-dross*** is assessed to be a ***Type 3*** waste material as per the Norms and Standards [7(6)] –

- *Notwithstanding section 7(2) of these Norms and Standards, wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCTO limits are considered to be Type 3 waste, irrespective of the total concentration of elements or chemical substances in the waste.*

# 5. RISK ASSESSMENT

As mentioned previously, Zn-Dross and Zn-Ash are waste products derived from the steel galvanising process to protect it from corrosion, amongst other benefits. These waste products contain between 94% and 99% Zn, which is then further beneficiated to remove impurities to form ZnO and $ZnSO_4$ that are sold for use in a variety of products such as skin care, fertiliser, dental care, animal feeds, etc. The reader is referred to Table 1 for the uses of ZnO and $ZnSO_4$. As mentioned previously, *Zn-Dross* and *Zn-Ash* are waste products derived from galvanising steel products to protect it from corrosion amongst other benefits. These waste products contain between 94% and 99% Zn, which is then further beneficiated to remove impurities to form ZnO and $ZnSO_4$ which are to be sold for use in a variety of products such as skin care, fertiliser, dental care, animal feeds, etc.

## 5.1 Impact Assessment methodology

An impact assessment is inherently a prediction of eventualities that could possibly/probably occur in future, based on an interpretation/assessment of data/information available at the time of compilation of such an assessment. The methodology that was employed during the impact assessment follows international best practice. The impact assessment considered the potential impacts of the proposed project activities on natural resources such as surface and groundwater resources and air. It is based on defining and understanding the three basic components of the risk, i.e. the source of the risk, the pathway and the target that experiences the risk (receptor).

The assessment focused on the identification of the major impacts that the activities, processes and actions may have on the receiving environment. It indicates the major impacts that these activities may have on the environmental components associated with handling, storing or transporting the material.

The risk assessment and management plan as contained within this report aimed to achieve the following:

- To provide an assessment of the environment that could potentially be affected by the proposed beneficial activities.
- To identify and recommend appropriate mitigation measures for potentially significant related impacts.

The environmental risk of each aspect was determined by considering a combination of parameters associated with the impact. Each parameter connects the physical characteristics of an impact to a quantifiable value to rate the environmental risk.

The impact assessment was conducted based on a methodology that included the following:

- Clear processes for impact identification, prediction and evaluation.
- Specification of the impact identification techniques.
- Criteria to evaluate the significance of impacts.
- Design of management measures to lessen impacts.
- Definition of the different types of impacts (indirect, direct or cumulative).

After identification of the impacts, the nature and scale of each impact was predicted. The impact prediction provided a basis from which the significance of each impact was determined. Appropriate mitigation measures were subsequently developed with the impact and scale of impact as reference.

## 5.2 Risk Assessment in terms of Regulation 8 of the Waste Exclusion Regulations

The environmental risk of any aspect is determined by a combination of parameters associated with the impact. Each parameter connects the physical characteristics of an impact to a quantifiable value to rate the environmental risk. The risk assessment methodology was based on the commonly adopted Source-Pathway-Receptor-Consequence model (Figure 3).

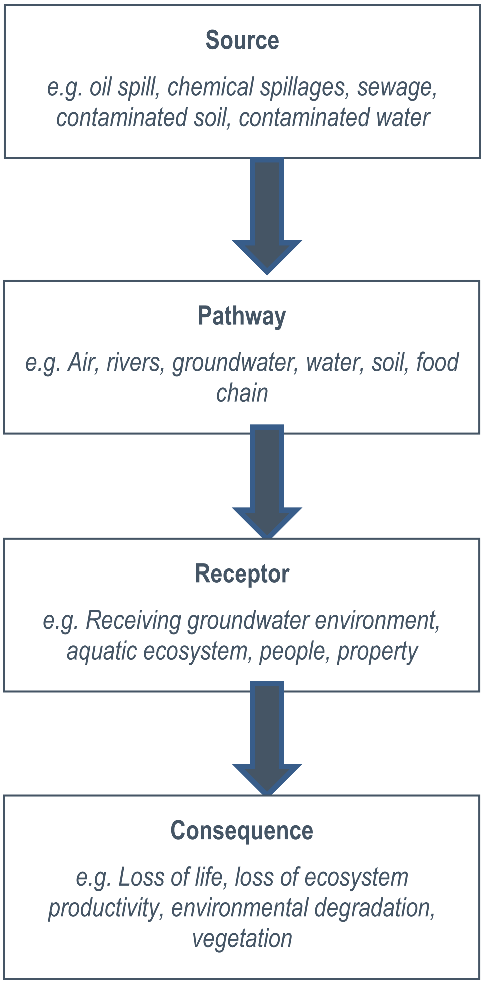


*Figure 3: Source – Pathway – Receptor-Consequence Conceptual model*

A prescribed set of factors and criteria were used to assess the impacts of the activities. These factors and criteria as proposed by the DFFE are shown in Table 13.

*Table 13: Factors and criteria used for the risk assessment*

| Criteria | |
|---|---|
| **MAGNITUDE (Severity)** | **DURATION** |
| 10 – Very high | 5 – Permanent (longer than 10 years) |
| 8 - High | 4 – Long-term (5 to 10 years) |
| 6 – Moderate | 3 – Medium-term (12 months to 5 years) |
| 4 – Low | 2 – Short-term (0 to 12 months) |
| 2 - Minor | 1 - Immediate |
| **SCALE** | **PROBABILITY (Likelihood)** |
| 5 - International | 5 – Definite |
| 4 – National | 4 – Highly probable |
| 3 – Regional | 3 – Medium probability |
| 2 – Local | 2 – Low probability |

| | |
|---|---|
| 1 – Site only | 1 – Improbable |
| 0 - None | 0 - None |

### Magnitude

Magnitude measures the size of the impact.

### Duration

Duration refers to the lifetime of the impact i.e. how long it will last.

### Scale

The scale refers to the extent of the impact.

### Probability

The probability refers to the chance of impact to occur. The potential impact could be most likely to occur, unlikely, etc.

### Assessment of Significance of impact

Significance rating of the potential impacts illustrates the importance of the impact itself. The size of area affected by pollution may be extremely high, but the significance of this effect is dependent on the concentration or level of pollution in that area. In order to determine the significance of impact, the following method was used:

*Significance Points (SP) = (Magnitude + Duration + Scale) x Probability*

The values of Significance Points ("SP") are then ranged as in Table 14:

*Table 14: Ratings and descriptions of the SP values*

| Rating | | Description |
|---|---|---|
| SP>60 | Indicates high environmental significance | An impact which could influence the decision about whether to proceed with the activities regardless of any possible mitigation. |
| SP 30 – 60 | Indicates moderate environmental significance | An impact or benefit which is sufficiently important to require management, and which could have an influence on the decision unless it is mitigated. |
| SP <30 | Indicates low environmental significance | Impacts with little real effect and which will not have an influence on or require modification of the activities. |
| + | Positive impact | An impact that is likely to result in positive consequences/effects. |

The risk is assessed without mitigation is shown in Table 15.

*Table 15: Risk Assessment without Mitigation*

| | ACTIVITY | RISK DESCRIPTION | ENVIRONMENTAL RECEPTORS | ASSESSMENT OF RISK | | | | | SIGNIFICANCE |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Impact | Probability | Magnitude | Duration | Scale | |
| 1 | Zinc Galvanizing (Galvanizing baths) at generating facility | Emissions | Atmosphere (air quality) | Air quality degradation | 5 | 6 | 4 | 1 | 55 |
| 2 | Storage of Zinc Dross and Zinc Ash at generating facility | Spillages (waste) if not contained and stored correctly | Soil | Soil contamination | 3 | 8 | 4 | 1 | 39 |
| 3 | Storage of Zinc Dross and Zinc Ash at generating facility | Spillages (waste) if not contained and stored correctly. Solid is insoluble in water | Surface water / runoff water | Surface/Storm water contamination | 2 | 8 | 4 | 2 | 28 |
| 4 | Storing Zinc Ash and Zinc Dross at generating facility | Dust - employee exposure | Atmosphere (air quality) | Employee health | 3 | 6 | 3 | 1 | 30 |
| 5 | Storage of Zinc Ash at generating facility | Ash catches fire spontaneously if exposed to moist air at elevated temperatures | Atmosphere (air quality - smoke) | Air quality degradation | 2 | 8 | 2 | 1 | 22 |
| 6 | Loading Zinc ash and dross at the generating facility | Dust and waste | Atmosphere (air quality) | Employee health | 4 | 6 | 1 | 1 | 32 |
| 7 | Loading Zinc ash and dross at the generating facility | Dust and waste | Soil | Soil contamination | 4 | 4 | 1 | 1 | 24 |
| 8 | Loading Zinc ash and dross at the generating facility | Dust - surface water runoff contamination | Surface water / runoff water | Surface/Storm water contamination | 4 | 4 | 4 | 2 | 40 |
| 9 | Loading Zinc ash and dross at the generating facility | Ash catches fire spontaneously if exposed to moist air at elevated temperatures | Atmosphere (air quality - smoke) | Air quality degradation | 2 | 6 | 2 | 2 | 20 |
| 10 | Transportation of Zinc ash and dross to the manufacturing facility | Ash catches fire spontaneously if exposed to moist air at elevated temperatures | Atmosphere (air quality - smoke) | Air quality degradation | 2 | 6 | 2 | 2 | 20 |
| 11 | Zinc Dross / Ash transported to zinc manufacturing facilities | Vehicle emissions and dust emissions if not transported correctly | Atmosphere (air quality) | Air quality | 3 | 4 | 2 | 2 | 24 |
| 12 | Zinc Dross / Ash transported to zinc manufacturing facilities | Dust and waste spillages if not transported correctly | Soil | Soil contamination | 2 | 6 | 2 | 1 | 18 |
| 13 | Zinc Dross / Ash transported to zinc manufacturing facilities | Dust and waste spillages if not transported correctly | Surface water / runoff water | Surface/Storm water contamination | 3 | 8 | 4 | 1 | 39 |

| | ACTIVITY | RISK DESCRIPTION | ENVIRONMENTAL RECEPTORS | ASSESSMENT OF RISK | | | | | SIGNIFICANCE |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Impact | Probability | Magnitude | Duration | Scale | |
| 14 | Zinc Dross / Ash transported to zinc manufacturing facilities | Accidents, spillage not cleaned after vehicle accident | Soil | Soil contamination | 3 | 6 | 2 | 1 | 27 |
| 15 | Zinc Dross / Ash transported to zinc manufacturing facilities | Accidents, spillage not cleaned after vehicle accident.<br>The solid is insoluble in water | Surface water / runoff water<br>Very toxic to aquatic life with long lasting effects | Surface/Storm water contamination | 3 | 8 | 4 | 2 | 42 |
| 16 | Storage of Zinc Dross and Zinc Ash at production site | Incorrect storage of dross and ash at the production site.<br>The solid is insoluble in water | Surface water / runoff water<br>Very toxic to aquatic life with long lasting effects | Surface/Storm water contamination | 3 | 8 | 3 | 2 | 39 |
| 17 | Zinc products manufacturing process - crushing | Dust from crushing if not controlled can increase employee exposure | Employee health | Employee health | 4 | 6 | 4 | 1 | 44 |
| 18 | Storing Zinc Ash and Zinc Dross at manufacturing facility | Ash catches fire spontaneously if exposed to moist air at elevated temperatures | Atmosphere (air quality - smoke) | Air quality degradation | 2 | 8 | 2 | 1 | 22 |
| 19 | Storing Zinc Ash and Zinc Dross at manufacturing facility | Spillages (waste) if not contained and stored correctly. Solid is insoluble in water | Surface water / runoff water | Surface/Storm water contamination | 2 | 8 | 4 | 2 | 28 |
| 20 | Zinc products manufacturing process - acid leach | Spillages and leaks from leaching tanks | Soil and groundwater | Soil and Run-off water contamination | 3 | 6 | 2 | 1 | 27 |
| 21 | Zinc products manufacturing process - acid leach | Inadequate bunding for leach tanks | Soil and groundwater | Soil and Run-off water contamination | 3 | 6 | 2 | 2 | 30 |
| 22 | Zinc products manufacturing process - acid leach | Emissions and vapours released from leach tanks | Atmosphere (air quality) | Air quality degradation | 4 | 6 | 4 | 1 | 44 |
| 23 | Zinc products manufacturing process - furnace | Emission control measures not adequate or not in good working condition | Atmosphere (air quality) | Air quality degradation | 5 | 6 | 2 | 2 | 50 |
| 24 | Zinc products manufacturing process - furnace fuel consumption | Natural gas /coal/fuel is used for the furnace | Use of natural resources | Depletion of natural resources | 2 | 4 | 5 | 3 | 24 |
| 25 | Zinc product manufacturing | Employee exposure | Air quality or water quality | Employee health | 4 | 6 | 4 | 1 | 44 |

| | ACTIVITY | RISK DESCRIPTION | ENVIRONMENTAL RECEPTORS | ASSESSMENT OF RISK | | | | | SIGNIFICANCE |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Impact | Probability | Magnitude | Duration | Scale | |
| 26 | Zinc Dross / Ash disposed to landfill (not reused by zinc product manufacturers) | Zinc and heavy metals leach | Groundwater | Groundwater contamination | 4 | 8 | 4 | 2 | 56 |
| 27 | Galvanised products ensure improved maintenance | Steel does not rust as fast | Less raw materials used | Environmental cost reduction | | | | | + |
| 28 | Galvanised products ensure quality manufacturing | The plant operation is more reliable, resulting in less products that does not pass a quality test | Increased resource efficiency | Environmental cost reduction | | | | | + |
| 29 | Galvanised steel is recyclable | Galvanised steel can be recycled | Increased resource efficiency | Efficient resource consumption | | | | | + |
| 30 | Galvanised steel has longevity, reduced maintenance cost and protection from rust. | Reduced maintenance cost required for structures build from galvanised steel | Increased resource efficiency | Environmental cost reduction | | | | | + |
| 31 | Galvanized steel is all around us and plays a vital role in our everyday lives. It is used in construction, transport, agriculture, power transmission and everywhere that corrosion protection and longevity are essential. | Reduced maintenance cost required for structures build from galvanised steel | Increased resource efficiency | Environmental cost reduction | | | | | + |
| 32 | Rarely is the zinc ore, as mined, rich enough to be used directly by smelters; it needs to be concentrated. Zinc ores contain 5-15% zinc. Zinc ash and Dross contain 70-96% zinc. | Mined zinc ore must be concentrated | Mine raw material | Efficient resource consumption | | | | | + |
| 33 | Zinc dross and zinc ash are important raw materials (product) for the zinc-processing industry. | Less raw materials mined | Mine raw material | Efficient resource consumption | | | | | + |
| 34 | Provision of employment, direct employment | Creation of infrastructure provide opportunities | Socio-economic | Socio-economic benefit | | | | | + |

| | ACTIVITY | RISK DESCRIPTION | ENVIRONMENTAL RECEPTORS | ASSESSMENT OF RISK | | | | | SIGNIFICANCE |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Impact | Probability | Magnitude | Duration | Scale | |
| 35 | Reduce waste to landfill | Save landfill airspace | Save landfill airspace | Efficient resource consumption | | | | | + |
| 36 | Reduction in carbon footprint | Less raw material mined, and less material transported | Reduce impact on climate change | Efficient resource consumption | | | | | + |
| 37 | This will make the landfill last longer and save on local taxes, as the expenses for the municipality will be reduced | Save on local tax expenditure | Socio economic benefit | Efficient resource consumption | | | | | + |
| 38 | Zinc dross and zinc ash are input materials for Zinc Oxide. | Less raw materials mined | Mine raw material | Efficient resource consumption | | | | | + |
| 39 | Zinc dross and zinc ash are input materials for Zinc Sulphate. | Less raw materials mined | Mine raw material | Efficient resource consumption | | | | | + |
| 40 | Zinc Oxide is used in products that protects the skin | Improved health, Reduce the risk of cancer | Human Health | Socio-economic benefit | | | | | + |
| 41 | Zinc Sulphate is used to add to fertiliser to improve Zinc deficiency in the diet | Improved health, Reduce childhood infections and diseases | Human Health | Socio-economic benefit | | | | | + |

# 6. RISK MANAGEMENT PLAN

The Risk Management Plan to be implemented by the facility is listed in Table 16.

*Table 16: Risk Management Plan for the application to exclude Zn-Ash Zn-Dross as a waste stream in terms of the National Environmental Management: Waste Act, 2008(Act No.59 of 2008), as amended*

| # | Activity | Risk Description | Action(s) to minimise/manage the risk | Responsibility (Who is responsible to carry out the action(s) |
|---|---|---|---|---|
| 1 | Zinc Galvanizing (Galvanizing baths) at generating facility | Emissions | Ensure air emission licence in place and audited annually<br>Emissions adhere to legal standards<br>Pollution control measures maintained and in good working condition | Galvanising facility |
| 2 | Storing Zinc Ash and Zinc Dross at generating facility | Spillages onto soil if not contained and stored correctly. | Store in a dedicated container that is protected from external corrosion. Ensure that storage containers are not overfilled.<br>Maintained bunded and demarcated storage area.<br>Clean-up any spillage that occur. | Galvanising facility |
| 3 | Storing Zinc Ash and Zinc Dross at generating facility | Spillages potentially contaminating run-off or storm water. The solid is insoluble in water | Clean-up any spillage that occur.<br>Ensure spills are cleaned prior to rainfall events.<br>Arrange for personnel to be trained on the spillage clean-up. | Galvanising facility |
| 4 | Storing Zinc Ash and Zinc Dross at generating facility | Dust - employee exposure | Ensure adequate signage and training because material (zinc ash) may be flammable when exposed to moist air at elevated temperatures | Galvanising facility |

| | | | | |
|---|---|---|---|---|
| 5 | Storing Zinc Ash at generating facility | Ash catches fire spontaneously if exposed to moist air at elevated temperatures | Clean up spills immediately.<br>Wear Protective Equipment.<br>Sweep up or absorb material, then place into a suitable clean, dry, dedicated closed container for disposal.<br>Avoid generating dusty conditions.<br>Remove open ignition sources<br>Use a spark-proof tool.<br>Provide ventilation.<br>Do not expose spill to water. | Galvanising facility |
| 6 | Loading Zinc ash and dross at the generating facility | Dust - employee exposure | All material handled and stored in containers.<br>Employee training in the handling and loading of Dross / Ash.<br>Correct PPE use during loading. | Galvanising facility & Transport contractor |
| 7 | Loading Zinc ash and dross at the generating facility | Dust - soil contamination | Employees use the correct PPE<br>Employee trained in the safe handling of Zinc ash and dross.<br>Clean contaminated areas. | Galvanising facility & Transport contractor |
| 8 | Loading Zinc ash and dross at the generating facility | Dust - surface water runoff contamination | Ensure that all contaminated runoff water is contained and managed and not discharged to any stormwater system, as it can be very toxic to aquatic life with long lasting effects | Galvanising facility & Transport contractor |
| 9 | Loading Zinc ash and dross at the generating facility | Ash catches fire spontaneously if exposed to moist air at elevated temperatures | Store ash in suitable clean, dry, closed containers<br>Avoid any contact with water during loading | Galvanising facility & Transport contractor |
| 10 | Transportation of Zinc ash and dross to the manufacturing facility | Ash catches fire spontaneously if exposed to moist air at elevated temperatures | Ensure compliance with dangerous goods transportation regulations.<br>Store ash in suitable clean, dry, closed containers<br>Avoid any contact with water | Transport contractor |

| | | | | |
|---|---|---|---|---|
| 11 | Transportation of Zinc ash and dross to the manufacturing facility | Vehicle emissions and dust emissions if not transported correctly | Material stored and handled in closed containers.<br>Ensure that vehicles are in good working condition and serviced regularly in line with service agreements. | Transport contractor |
| 12 | Transportation of Zinc ash and dross to the manufacturing facility | Dust and waste spillages if not transported correctly impacting on air quality | Implement spillage procedure.<br>Ensure spill kits are easily assessable.<br>Arrange for personnel to be trained on the spillage procedure. | Transport contractor |
| 13 | Transportation of Zinc ash and dross to the manufacturing facility | Dust and waste spillages if not transported correctly impacting on water quality | Implement spillage procedure.<br>Ensure spill kits are easily assessable.<br>Arrange for personnel to be trained on the spillage procedure.<br>Ensure that all dust or waste spillages that could contaminated runoff water is contained and managed and not discharged to any stormwater system, as it can be very toxic to aquatic life with long lasting effects | Transport contractor |
| 14 | Transportation of Zinc ash and dross to the manufacturing facility | Accidents, dust, or waste spillage not cleaned after vehicle accident | Implement spillage procedure.<br>Ensure spill kits are easily assessable.<br>Arrange for personnel to be trained on the spillage procedure. | Transport contractor |
| 15 | Transportation of Zinc ash and dross to the manufacturing facility | Accidents, spillage not cleaned after vehicle accident, resulting in run-off water contamination<br>The solid is insoluble in water | Implement spillage procedure.<br>Ensure spill kits are easily assessable.<br>Arrange for personnel to be trained on the spillage procedure.<br>Ensure that all dust or waste spillages that could contaminated runoff water is contained and managed and not | Transport contractor |

| | | | | |
|---|---|---|---|---|
| | | | discharged to any stormwater system, as it can be very toxic to aquatic life with long lasting effects | |
| 16 | Storage of Zinc Dross and Zinc Ash at production site | Incorrect storage of dross and ash at the production site.<br>The solid is insoluble in water | Store in a dedicated container that is protected from external corrosion. Ensure that storage containers are not overfilled.<br>Maintained bunded and demarcated storage area.<br>Clean-up any spillage that occur. | Receiving facility |
| 17 | Zinc products manufacturing process - crushing | Dust from crushing if not controlled can increase employee exposure | Emission extraction and air pollution control measures and equipment maintained in good working condition.<br>Employee training in the correct handling of material during crushing.<br>Ensure adequate signage and training because material (zinc ash) may be flammable when exposed to moist air at elevated temperatures.<br>Use of correct PPE. | Receiving facility |
| 18 | Storing Zinc Ash and Zinc Dross at manufacturing facility | Ash catches fire spontaneously if exposed to moist air at elevated temperatures | Clean up spills immediately.<br>Wear Protective Equipment.<br>Sweep up or absorb material, then place into a suitable clean, dry, dedicated closed container for disposal.<br>Avoid generating dusty conditions.<br>Remove open ignition sources.<br>Use a spark-proof tool.<br>Provide ventilation.<br>Do not expose spill to water. | Receiving facility |
| 19 | Storing Zinc Ash and Zinc Dross at manufacturing facility | Spillages (waste) if not contained and stored correctly. Solid is insoluble in water. Soil | Storage in dedicated containers.<br>Clean-up any spillage that occur. | Receiving facility |

| | | | | |
|---|---|---|---|---|
| | | contamination and runoff water contamination | Ensure spills are cleaned prior to rainfall events.<br>Arrange for personnel to be trained on the spillage clean-up. | |
| 20 | Zinc product manufacturing | Spillages and leaks from leaching tanks | Tank's integrity checked on annual basis<br>Bunds maintained in good condition<br>Daily site inspections<br>Implement spillage procedure.<br>Ensure spill kits are easily assessable.<br>Arrange for personnel to be trained on the spillage procedure. | Receiving facility |
| 21 | Zinc products manufacturing process - acid leach | Inadequate bunding for leach tanks | Tank's integrity checked on annual basis<br>Bunds maintained in good condition<br>Daily site inspections<br>Implement spillage procedure.<br>Ensure spill kits are easily assessable.<br>Arrange for personnel to be trained on the spillage procedure. | Receiving facility |
| 22 | Zinc product manufacturing | Emissions and vapours released from leach tanks | Ensure air emission licence in place and audited annually<br>Emissions adhere to legal standards<br>Pollution control measures maintained and in good working condition | Receiving facility |
| 23 | Zinc products manufacturing process - furnace | Emission control measures not adequate or not in good working condition | Emission extraction and air pollution control measures.<br>Ensure pollution control equipment maintained in good working condition.<br>Compliance with air emission legal standards. | Receiving facility |

| | | | | |
|---|---|---|---|---|
| 24 | Zinc product manufacturing | Resource consumption | All equipment and machines maintained in good working condition<br>monitor consumption | Receiving facility |
| 25 | Zinc product manufacturing | Employee exposure | Employee training in terms of operational procedures<br>Employee medicals<br>occupational hygiene risk assessments and surveys in place as required by the OHSA<br>Use of correct PPE | Receiving facility |
| 26 | Zinc Dross / Ash disposed to landfill (not reused by zinc product manufacturers) | Zinc and heavy metals leach | Reuse Zinc Dross / Ash to prevent disposal to landfill | Landfill facility |

## 6.1 Mechanism to record the amount of waste distributed

Section 9c of the Regulations (No. 715) states that the applicant must have a mechanism in place to record the amount of waste distributed to specific users for a permitted use, including the number of enterprises established or supported and the extent to which previously disadvantaged individuals have been supported.

At the galvanising units, the ash and dross waste materials are loaded onto skips and weighed on a weigh bridge and a waste manifest is prepared. It is then sold to the facility that recycles the waste material into ZnO and $ZnSO_4$.

## 6.2 Recovery of zinc By Pyrometallurgy and/or Hydrometallurgy

Recycling of zinc to $ZnSO_4$ and ZnO and its component by-products is done through two processes, pyrometallurgy and hydrometallurgy. Regarding post beneficiation and content, refer to Safety Data Sheets (SDS) for $ZnSO_4$ and ZnO appended.

In pyro-metallurgy, zinc-rich materials are heated in air to produce zinc vapor, which is then condensed to form Zn metal. In hydrometallurgy, Zn-rich materials are leached with sulfuric acid to produce $ZnSO_4$, which is then electrolyzed to form zinc metal.

### 6.2.1 Pyrometallurgy

In a commercial Zn metal recycling workshop, several distillation furnaces, a ground furnace, and also a ball mill is typically used:

- Distillation furnace (for dross and associated zinc-rich lumps) (Figure 4)
- Ground furnace (for extraction of ash and zinc-oxide residues)
- Ball mill (for screening and separation of zinc-rich parts from ash and slag)

Ibrahim *et. al.* (2019) conducted a bench scale system for pyrometallurgical Zn recovery. The schematic presentation of this system shown in Fig. 4. The system consists of a furnace as a heating source. A silicon carbide crucible which could hold about 1 kg Zn-dross. The crucible was connected to a silicon carbide tube which can withstand high temperature as high as 1200°C.

The end of the silicon carbide tube is connected to a second crucible in which recovered zinc is received. Figure 5a represents the two crucibles connected by the SIC tube while Fig. 5b represents the heating crucible inside the furnace while the receiving crucible outside the furnace. This system was perfectly insulated using ceramic fibre from surrounding (Fig. 5c). Silicon carbide tube with sealed to both crucibles using thermal cement which succeeded in preventing any leakage during the experiment.

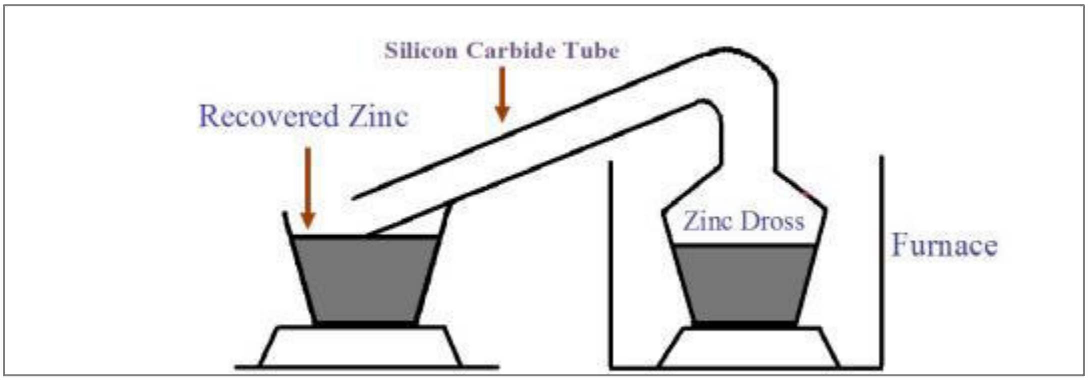


*Figure 4: Schematic presentation of the pyrometallurgical system used for Zn recovery from Zn-dross (from Ibrahim, et. al., 2019)*

*Figure 5: bench scale system for pyrometallurgical Zn recovery*

The Zn recoverable from the pyrometallurgical system used for Zn recovery and recovered zinc from Zn-dross are displayed in Figure 6.

*Figure 6: A photograph of the pyrometallurgical system used for Zn recovery and recovered zinc from Zn-dross*

Weighed and chemically analysed Zn either formed in the condensation (receiving) crucible or the SIC tube is displayed in Table 17. Almost pure Zn (99.95%) is obtained using this method (Ibrahim, *et. al.*, 2019).

*Table 17: Chemical analysis of Zn formed after lab scale pyrometallurgical experiments performed at 1050°C* (*from Ibrahim, et. al., 2019*)

| **Metal%** | **%Fe** | **%Al** | **%Zn** |
|---|---|---|---|
| Zn produced in the receiving crucible | 0.028 | 0.015 | 99.95 |
| Zn found in the SiC tube | 0.053 | 0.04 | 99.91 |
| Powder in the receiving crucible | 0.18 | 0.11 | 99.7 |
| Ash remained in the heating crucible | 0.11 | 43.79 | 5.64 |

Pyrometallurgical method is considered quick, requires relatively small space and considered economic regarding energy consumption because the furnace can work with natural gas.

### 6.2.2 Hydrometallurgy

Hydrometallurgy has evolved, both as an alternative to and a complementary method for the pyrometallurgical recovery of zinc. It makes it economically viable to recover zinc on a smaller scale. Hydrometallurgy provides for a more direct zinc-recovery route, reducing working capital. Through research and development, hydrometallurgical processing has made steady progress by making better use of resources including water, energy, and available land, greatly improving both capital and operating costs and reducing atmospheric emissions.

A Zn material balance sheet is shown in Figure 7 below. High grade Zn of up to 99.99% is used for the galvanising process. Zn-Ash and Dross are waste by-products formed, which is then sold to Zn refining and metallurgical processing companies to process the waste into high grade $ZnSO_4$ and ZnO. These ultra-pure Zn products are used again during the galvanising process and other industries including agriculture, pharmaceuticals and cosmetics, batteries and renewable energy, etc.

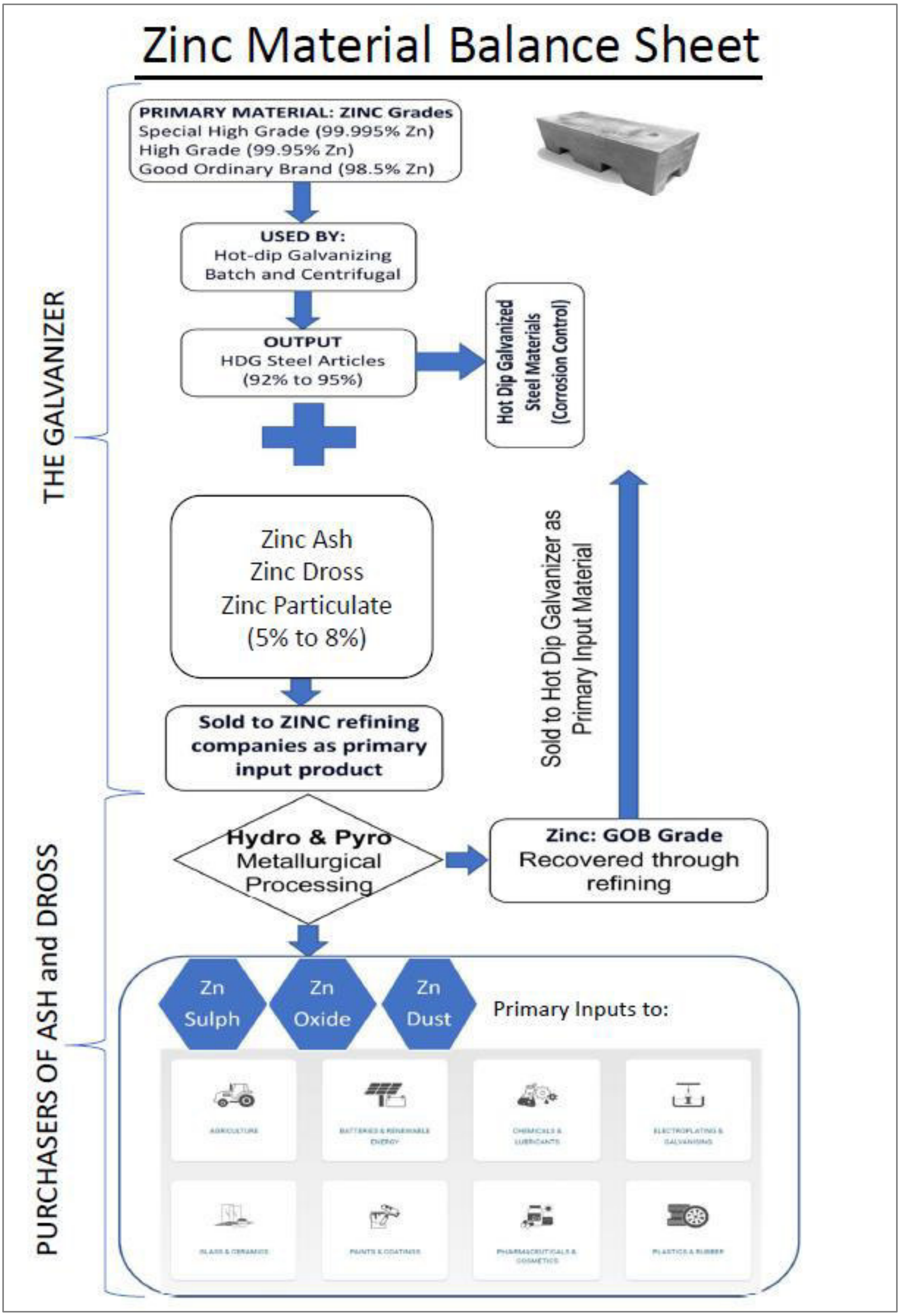


*Figure 7: Zn material balance sheet*

## 6.3 Beneficial uses locally or internationally of the waste material

As per requirements of the GN 715 in GG 41777 of 18 July 2018, Regulation 7 (a) (Regulations Regarding the Exclusion of a Waste Stream or a Portion of a Waste Stream from the Definition of Waste), the application must demonstrate that the waste is being or has been or will be used for a beneficial purpose either locally or internationally. Below is references to literature where the waste materials generated can be used for beneficial use.

Recycling of materials from industrial processes reduces amount of waste to be finally disposed. *Zn-Ash* and *Zn-Dross* contain valuable Zn that can be recovered and reused, making them important from both economic and environmental points of view. Zinc (Zn) is one of a few metals which can be recycled at all stages of the production and usage. It is estimated that over 80% of Zn available for recycling is currently recycled, while up to 30–40% of zinc consumed comes from reclaimed Zn sources (Ng et al., 2016; van Beers et al., 2007).

Waste with high Zn percentages such as *Zn-Dross* and *Zn-Ash* can be used as a valuable source of ZnO and $ZnSO_4$. Zn is a tradable commodity and can improve sustainable consumption and divert waste from landfills by using the *Zn-Ash* and *Zn-Dross* waste materials (containing up to 99% of Zn) as a valuable source of secondary Zn.

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# APPENDIX A

## Waste Generating Facilities

## Appendix A: Waste Generating Facilities:

| No. | Galvanising Facility | Area and Province | Address |
|---|---|---|---|
| 1 | Transvaal Galvanisers (Pty) | Nigel, Gauteng | 3 3rd Ave, Vosterkroon, Nigel |
| 2 | Armco Superlite | Kempton Park, Gauteng | 131 Anvil Road, Isando, Kempton Park |
| 3 | Armco Superlite (Randfontein) | Randfontein, Gauteng | 23 Fiat Street, Aureus, Randfontein, 1759 |
| 4 | Silverton Engineering | Pretoria, Gauteng | 318 Derdepoort Road, Silverton 0184 |
| 5 | SMT Group | Benoni, Gauteng | 5 Lincoln Road, Benoni South, Benoni, 1501 |
| 6 | Galferro Galvanisers | Springs, Gauteng | Corner Radon and Neon Road, Fulcrum, Springs, 1559 |
| 7 | Lianru Galvanisers | Nigel, Gauteng | 14 5th Avenue, Nigel,1491 |
| 8 | Pro-Tech Galvanizers (Pty) Ltd | Nigel, Gauteng | 12 Fabriek Crescent, Vosterkroon, Nigel |
| 9 | Agrico | Lichtenburg, North West | 29 Kalkweg Way, M.C Van Niekerkpark, Lichtenburg, 2740 |
| 10 | Galvanising Techniques (Metalman Pty Ltd) | Port Elizabeth, Eastern Cape | 52 Burman Road, Deal Party, PE, 6001 |
| 11 | Sable Sands t/a Morhot Galvanizers | Mdantsane, Eastern Cape | 4 Indwe Road, Fort Jackson Industrial, Mdantsane |
| 12 | Pinetown Galvanizing | Pinetown, Kwazulu Natal | 38 Hillclimb Road, Westmead Ext1, Pinetown, 3610 |
| 13 | Durban Galvanizing Plant 'A' | Durban, Kwazulu Natal | 64 Marseilles Crescent, Briardene, Durban, 4016 |
| 14 | Durban Galvanizing Plant 'B' | Durban, Kwazulu Natal | 274 Aderdare drive, Phoenix Industrial, Durban, 4068 |
| 15 | KZN Galvanizers | Pietermaritzburg, Kwazulu Natal | 174 Ohrtmann Road, Willowton, Pietermaritzburg, 3201 |
| 16 | Bay Galvanisers | Richards Bay, Kwazulu Natal | 110 Alumina Alee Street, Richards Bay, 3900 |
| 17 | Advanced Galvanising (Pty) Ltd | Cape Town, Western Cape | Dorbyl Street, Sacks Circle, Bellville, Cape Town, 7530 |
| 18 | South Cape Galvanizing (Pty) Ltd | George, Western Cape | 11 Ring Road, George Industrial, George |

## Appendix B: GPS Coordinates:

## GAUTENG

1. Transvaal Galvanisers (Pty) Ltd

Site Address: 3, 3rd Ave, Vosterkroon, Nigel, 1490.

**Hot Dip Galvanizing Facilities GPS Co-ordinates (DMS Format)**

| **Batch HDG Plant Corner** | **Latitude** | **Longitude** |
|---|---|---|
| 1 | 26°23’59.8524” S | 28°28'48.4140" E |
| 2 | 26°24'1.6380” S | 28°28’51.5172" E |
| 3 | 26°24'3.7116" S | 28°28'50.0376" E |
| 4 | 26°24'1.9188" S | 28°28'46.9020" E |
| **Dragline HDG Plant Corner** | **Latitude** | **Longitude** |
| 1 | 26°24'2.8944" S | 28°28’51.6648" E |
| 2 | 26°24’5.7960" S | 28°28’55.9092" E |
| 3 | 26°24'6.4764" S | 28°28'55.4340" E |
| 4 | 26°24'3.7620" S | 28°28’50.9268" E |

2. Armco Superlite Isando

Site Address: 131 Anvil Road, Isando, Kempton Park, 1600

**Hot Dip Galvanizing Facilities GPS Co-ordinates (DMS Format)**

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 26° 8’8.3256" S | 28°12’36.7092" E |
| 2 | 26° 8'11.2668" S | 28°12’36.6120" E |
| 3 | 26° 8'11.2920" S | 28°12'36.0216" E |
| 4 | 26° 8'8.2968" S | 28°12'36.0900" E |

3. Armco Superlite (Randfontein)

Address: 23 Fiat Street, Aureus, Randfontein, 1759

**Hot Dip Galvanizing Facilities GPS Co-ordinates (DMS Format)**

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 26°11'54.5856" S | 27°41'43.5084" E |
| 2 | 26°11'55.2120" S | 27°41'44.8296" E |
| 3 | 26°11'55.6080" S | 27°41'44.5740" E |
| 4 | 26°11'54.9924" S | 27°41'43.2888" E |

4. Silverton Engineering

Address: 318 Derdepoort Road, Silverton 0184

**Hot Dip Galvanizing Facilities GPS Co-ordinates (DMS Format)**

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 25°43’26.4972” S | 28°17’53.1168" E |
| 2 | 25°43’28.6716” S | 28°17’53.8116" E |
| 3 | 25°43’28.7256” S | 28°17’53.0916" E |
| 4 | 25°43’26.6520” S | 28°17’52.4724" E |

5. SMT Group

Address: 9 Lincoln Road, Benoni South, Benoni, 1501

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 26°12’18.06” S | 28°18’07.55" E |
| 2 | 26°12’17.77” S | 28°18’08.05" E |
| 3 | 26°12’18.14” S | 28°18’08.37" E |
| 4 | 26°12’18.44” S | 28°18’07.80" E |

6. Galferro Galvanisers

Address: Corner Radon and Neon Road, Fulcrum, Springs, 1559

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 26°16’29.42” S | 28°23’53.89" E |
| 2 | 26°16’25.85” S | 28°23’54.42" E |
| 3 | 26°16’26.02” S | 28°23’55.95" E |
| 4 | 26°16’29.52” S | 28°23’55.41" E |

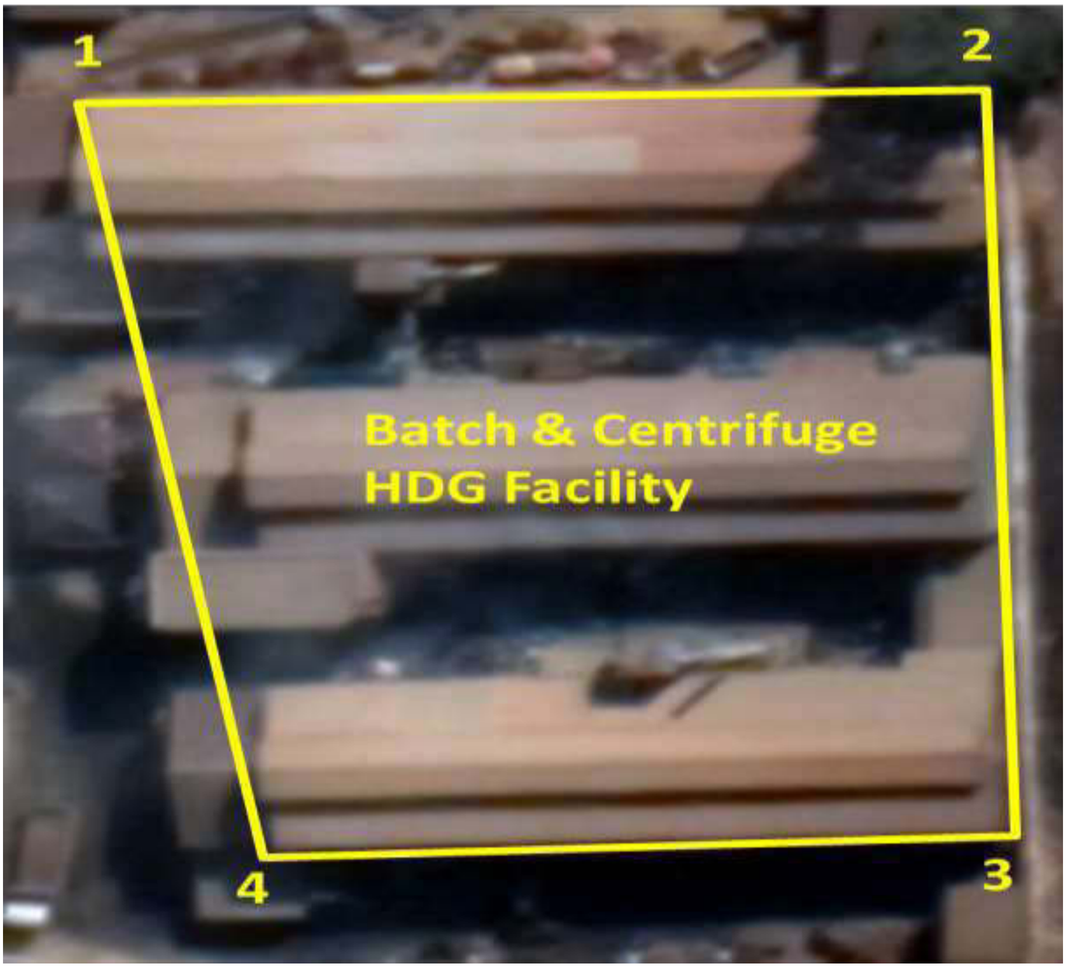
7. Lianru Galvanisers

14, 5th Avenue, Nigel,1491

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 26°24’04.10” S | 28°28’30.22" E |
| 2 | 26°24’05.35” S | 28°28’32.40" E |
| 3 | 26°24’06.76” S | 28°28’31.41" E |
| 4 | 26°24’05.51” S | 28°28’29.20" E |

8. Pro-Tech Galvanizers (Pty) Ltd

Address: 12 Fabriek Crescent, Vosterkroon, Nigel

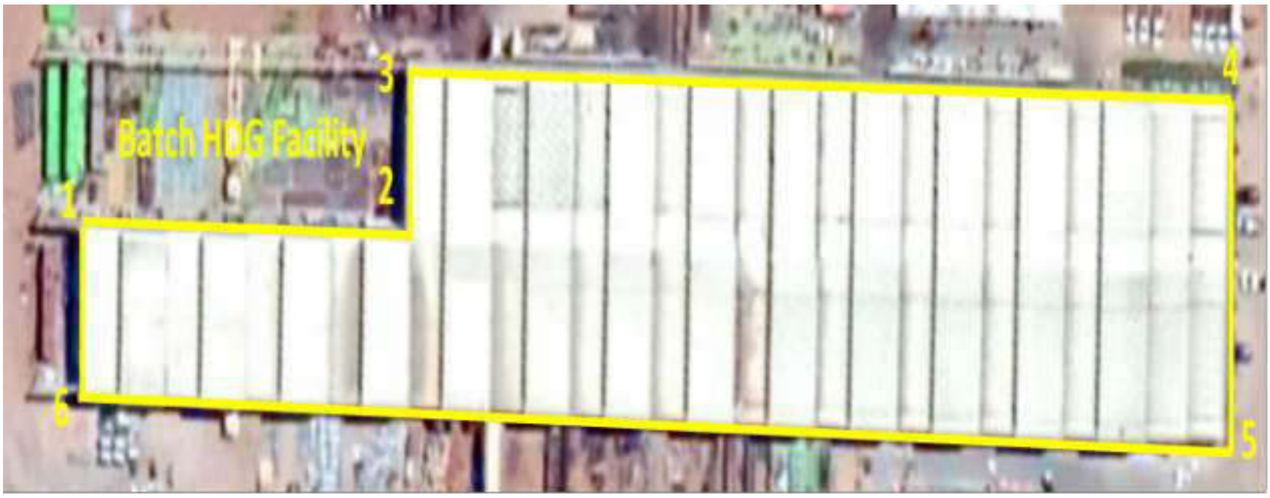


| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 26°23’47.81” S | 28°28’27.01" E |
| 2 | 26°23’47.56” S | 28°28’44.09" E |
| 3 | 26°23’49.40” S | 28°28’44.47" E |
| 4 | 26°23’49.61” S | 28°28’43.01" E |

**NORTH WEST**

9. Agrico

29 Kalkweg Way, M.C Van Niekerkpark, Lichtenburg, 2740



| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 26°10’33.23” S | 26°09’51.74" E |
| 2 | 26°10’33.97” S | 26°09’53.86" E |
| 3 | 26°10’33.41” S | 26°09’54.10" E |
| 4 | 26°10’35.30” S | 26°09’59.44" E |
| 5 | 26°10’36.41” S | 26°09’58.96" E |
| 6 | 26°10’33.79” S | 26°09’51.47" E |

## **EASTERN CAPE**

10. Galvanising Techniques (Metalman Pty Ltd)

52 Burman Road, Deal Party, PE, 6001

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 33°54’15.61” S | 25°36’49.89" E |
| 2 | 33°54’15.13” S | 25°36’47.12" E |
| 3 | 33°54’13.58” S | 25°36’47.50" E |
| 4 | 33°54’14.04” S | 25°36’50.27" E |

11. Sable Sands t/a Morhot Galvanizers

4 Indwe Road, Fort Jackson Industrial, Mdantsane

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 32°55’20.54” S | 27°41’45.89" E |
| 2 | 32°55’20.29” S | 27°41’50.67" E |
| 3 | 32°55’20.85” S | 27°41’50.75" E |
| 4 | 32°55’21.27” S | 27°41’45.94" E |

## KWAZULU NATAL

12. Pinetown Galvanizing

38 Hillclimb Road, Westmead Ext1, Pinetown, 3610

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 29°48’56.75” S | 30°49’19.19" E |
| 2 | 29°48’58.29” S | 30°49’19.12" E |
| 3 | 29°48’58.09” S | 30°49’17.77" E |
| 4 | 29°48’56.47” S | 30°49’18.72" E |

## 13. Durban Galvanizing - Plant 'A'

64 Marseilles Crescent, Briardene, Durban, 4016

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 29°47’48.03” S | 30°00’38.23" E |
| 2 | 29°47’49.73” S | 30°00’40.72" E |
| 3 | 29°47’50.23” S | 30°00’40.22" E |
| 4 | 29°47’48.56” S | 30°00’37.77" E |

14. Durban Galvanizing - Plant 'B'

274 Aberdare drive, Phoenix Industrial, Durban, 4068

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 29°43’10.28” S | 31°00’00.13" E |
| 2 | 29°43’06.72” S | 31°00’04.02" E |
| 3 | 29°43’07.18” S | 31°00’04.52" E |
| 4 | 29°43’10.69” S | 31°00’00.66" E |

15. KZN Galvanizers

174 Ohrtmann Road, Willowton, Pietermaritzburg, 3201

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 29°35’35.62” S | 30°24’45.75" E |
| 2 | 29°35’36.70” S | 30°24’45.86" E |
| 3 | 29°35’36.77” S | 30°24’45.54" E |
| 4 | 29°35’35.74” S | 30°24’45.19" E |

16. Bay Galvanisers

110 Alumina Alee Street, Richards Bay, 3900

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 28°44’36.20” S | 32°02’07.17" E |
| 2 | 28°44’35.15” S | 32°02’07.75" E |
| 3 | 28°44’35.34” S | 32°02’08.20" E |
| 4 | 28°44’36.38” S | 32°02’07.63" E |

## WESTERN CAPE

17. Advanced Galvanising (Pty) Ltd,

Dorbyl Street, Sacks Circle, Bellville, Cape Town, 7530

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 33°55’29.59” S | 18°38’11.37" E |
| 2 | 33°55’29.63” S | 18°38’13.89" E |
| 3 | 33°55’31.11” S | 18°38’13.96" E |
| 4 | 33°55’31.12” S | 18°38’11.39" E |

18. South Cape Galvanizing (Pty) Ltd

11 Ring Road, George Industrial, George

| Corner | Latitude | Longitude |
|---|---|---|
| 1 | 33°58’46.29” S | 22°27’10.13" E |
| 2 | 33°58’46.37” S | 22°27’12.16" E |
| 3 | 33°58’47.05” S | 22°27’12.12" E |
| 4 | 33°58’46.97” S | 22°27’10.06" E |

# APPENDIX B

## Laboratory Certificates

ANALYTICAL & CONSULTING

Dr Sabine Verryn

m: 083 548 0586
f: 086 565 7368
e: sabine.verryn@xrd.co.za

XRD Analytical and Consulting cc
75 Kafue Street, Lynnwood Glen,
0081, South Africa

**CLIENT:** UIS

**DATE:** 20 February 2023

**SAMPLES:** 2 Samples (Request 50174)

**ANALYSIS:** Qualitative and quantitative XRD

The material was prepared for XRD analysis using a back-loading preparation method.

Diffractograms were obtained using a Malvern Panalytical Aeris diffractometer with a PIXcel detector and fixed slits with Fe-filtered Co-Kα radiation. The phases were identified using X'Pert Highscore plus software

The relative phase amounts (weight %) were estimated using the Rietveld method.

**Comment:**

- In case the results do not correspond to the results of other analytical techniques, please let me know for further fine-tuning of XRD results.
- Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group. The metallic phases in the dross sample seem of different crystal structures – compositions have to be confirmed.
- Due to preferred orientation and crystallite size effects, results may not be as accurate as shown.
- Traces of additional phases may be present. Amounts below 0.5 weight % may be unreliable.
- Amorphous phases, which may be present, were not taken into consideration during quantification.

If you have any further queries, kindly contact me.

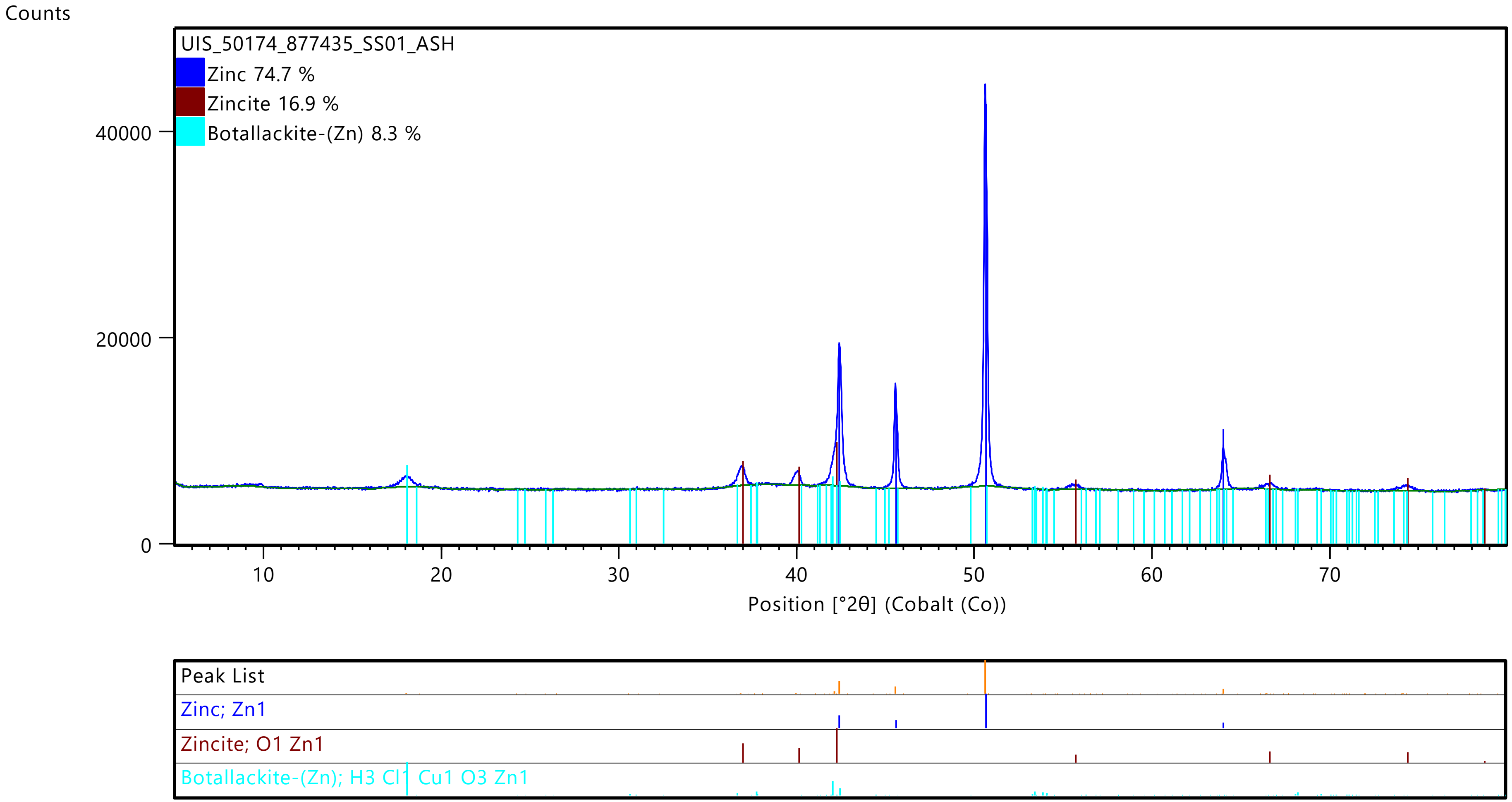
SVerryn.

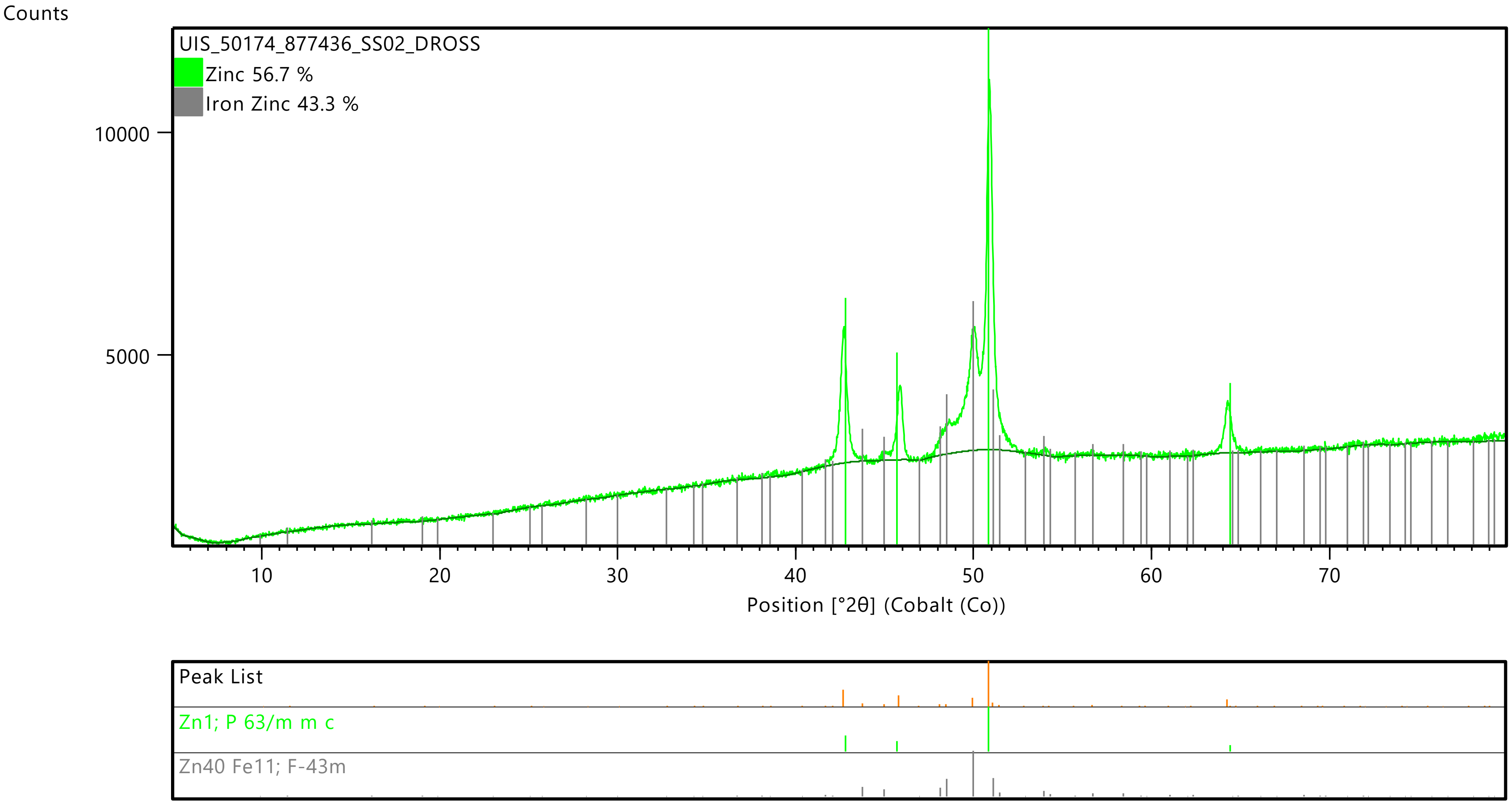
Dr. Sabine Verryn (Pr.Sci.Nat)

**Samples will be stored for 3 months after which they will be discarded.**

| | | | |
|---|---|---|---|
| | **Zinc** | **Zincite** | **Botallackite-(Zn)** |
| **UIS_50174_877435_SS01_ASH** | 74.72 | 16.95 | 8.34 |
| | **Zinc** | **Iron Zinc** | |
| **UIS_50174_877436_SS02_DROSS** | 56.66 | 43.34 | |

0 = n.d. – not detected above the detection limit of 0.5-3 weight percent


Counts
UIS_50174_877435_SS01_ASH
Zinc 74.7 %
Zincite 16.9 %
Botallackite-(Zn) 8.3 %
40000
20000
0
10
20
30
40
50
60
70
Position [°2θ] (Cobalt (Co))
Peak List
Zinc; Zn1
Zincite; O1 Zn1
Botallackite-(Zn); H3 Cl1 Cu1 O3 Zn1


Counts
UIS_50174_877436_SS02_DROSS
🟩 Zinc 56.7 %
▨ Iron Zinc 43.3 %
10000
5000
10
20
30
40
50
60
70
Position [°2θ] (Cobalt (Co))
Peak List
Zn1; P 63/m m c
Zn40 Fe11; F-43m

# ANALYTICAL REPORT: Water Leach

No unauthorised copies may be made of this report.

**To:** **GIY Hydroponics Trading as AquiScience**
**Attention:** **Ockie Scholtz**
**Project ID:** **Q-GEO-23/00285 (HDGSA)**
**Site Location:**
**Order No:**

Date of Request :03.02.2023

UIS Analytical Services
Analytical Chemistry
Laboratories 4, 6

Fax: (012) 665 4294

**Certificate of analysis: 50174**

Note: all results in parts per million (ppm) unless specified otherwise

| Lims ID | Sample ID | Ag | Al | As | Au | B | Ba | Be | Bi | Ca | Cd | Ce | Co | Cr | Cs | Cu | Fe | Ga | Ge | Hf | Hg | Ho | Ir | K | La | Li | Mg | Mn | Mo | Na | Nb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **WATER LEACH (1:20)** | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l |
| | **LEACH BLANK** | <0.001 | <0.01 | <0.001 | <0.001 | <0.001 | 0.003 | <0.001 | <0.001 | <0.01 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.01 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.084 | <0.001 | <0.001 | <0.01 | <0.001 | <0.001 | 0.069 | <0.001 |
| **877437** | **SS01-ASH/WATER/LEACH** | 0.001 | <0.01 | 0.001 | <0.001 | 0.061 | 0.285 | <0.001 | <0.001 | 9.567 | <0.001 | 0.018 | 0.003 | <0.001 | <0.001 | 0.093 | 0.390 | 0.016 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 19.634 | 0.009 | 0.003 | 0.799 | 45.415 | 0.025 | 27.104 | <0.001 |
| | **duplicate** | 0.001 | <0.01 | 0.002 | <0.001 | 0.057 | 0.230 | <0.001 | <0.001 | 8.068 | <0.001 | 0.018 | 0.004 | <0.001 | <0.001 | 0.096 | 0.584 | 0.016 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 19.847 | 0.010 | 0.003 | 0.552 | 46.753 | 0.030 | 26.456 | <0.001 |
| **877438** | **SS02-DROSS/WATER/LEACH** | <0.001 | <0.01 | <0.001 | <0.001 | <0.001 | 0.014 | <0.001 | <0.001 | 1.221 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.01 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.185 | <0.001 | <0.001 | 0.040 | 0.012 | <0.001 | 0.465 | <0.001 |

| | | pH | pH Temp | TDS | EC | TDS by Sum | TDS by EC | P Alk. | M Alk. | F | Cl | NO2 | NO3 | NO3 as N | PO4 | SO4 | Sum of Cations | Sum of Anions | Ion Balance | NH4 | NH3 as N | Cr 6+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **WATER LEACH (1:20)** | | Deg C | mg/l | mS/m | mg/l | mg/l | mg/l CaCO3 | mg/l CaCO3 | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | me/l | me/l | % | mg/l | mg/l | mg/l |
| | **LEACH BLANK** | 7.26 | 25 | <30 | 1 | n/a | 4 | <0.6 | 3.50 | <0.1 | <0.25 | <0.2 | <0.3 | <0.1 | <0.8 | 0.59 | n/a | n/a | n/a | <0.25 | <0.25 | <0.05 |
| **877437** | **SS01-ASH/WATER/LEACH** | 6.36 | 25 | 5182 | 842 | 5794 | 5896 | <0.6 | 32.5 | 0.96 | 2906 | <0.2 | <0.3 | <0.1 | <0.8 | 1.07 | 101.3 | 82.9 | 9.9 | 517 | 402 | <0.05 |
| | **duplicate** | 6.45 | 25 | 5122 | 827 | 5929 | 5789 | <0.6 | 33.4 | 0.98 | 2921 | <0.2 | <0.3 | <0.1 | <0.8 | 1.14 | 104.9 | 83.4 | 11.4 | 517 | 402 | <0.05 |
| **877438** | **SS02-DROSS/WATER/LEACH** | 8.07 | 25 | <30 | 1 | 6 | 5 | <0.6 | 5.50 | <0.1 | <0.25 | <0.2 | <0.3 | <0.1 | <0.8 | <0.3 | 0.092 | 0.116 | -11.5 | <0.25 | <0.25 | <0.05 |

| | | |
|---|---|---|
| Chemical elements: | Ag, Al, As, Au, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, Ge, Hf, Hg, Ho, Ir, K, La, Li, Mg, Mn, Mo, Na, Nb, Nd, Ni, Pb, Pt, Rb, Sb, Sc, Se, Si, Sn, Sr, Ta, Te, Th, Ti, Tl, U, V, W, Y, Zn, Zr | Anions, pH, NH4, Alkalinity, CN, Cr6+ |
| Instrument: | ICP-MS Perkin Elmer NexION 300D   Ion Chromatography   Spectrophotometer   Ion Selective Probe | |

| | | | |
|---|---|---|---|
| Date: | 16/03/2023 | Date: | 2023.04.18 |
| Analysed by: | UIS Waterlab/Ricardo Kayser | Authorised : | JJ Oberholzer |

**To:** GIY Hydroponics Trading as AquiScience
**Attention:** Ockie Scholtz
**Project ID:** Q-GEO-23/00285 (HDGSA)
**Site Location:**
**Order No:**

| Lims ID | Sample ID | Nd | Ni | Pb | Pt | Rb | Sb | Sc | Se | Si | Sn | Sr | Ta | Te | Th | Ti | Tl | U | V | W | Y | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **WATER LEACH (1:20)** | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l |
| | **LEACH BLANK** | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | <0.01 | <0.001 | 0.002 | <0.001 | <0.001 | <0.001 | <0.01 | <0.001 | <0.001 | 0.003 | <0.001 | <0.001 | <0.001 | <0.001 |
| **877437** | **SS01-ASH/WATER/LEACH** | <0.001 | 0.258 | 0.123 | <0.001 | 0.007 | <0.001 | <0.001 | 0.004 | <0.01 | <0.001 | 0.038 | <0.001 | <0.001 | <0.001 | <0.01 | 0.007 | <0.001 | 0.004 | <0.001 | <0.001 | 2246 | <0.001 |
| | **duplicate** | <0.001 | 0.272 | 0.143 | <0.001 | 0.007 | <0.001 | <0.001 | 0.003 | <0.01 | <0.001 | 0.033 | <0.001 | <0.001 | <0.001 | <0.01 | 0.006 | <0.001 | 0.003 | <0.001 | <0.001 | 2366 | <0.001 |
| **877438** | **SS02-DROSS/WATER/LEACH** | <0.001 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.003 | <0.01 | <0.001 | 0.004 | <0.001 | <0.001 | <0.001 | <0.01 | <0.001 | <0.001 | 0.003 | <0.001 | <0.001 | 0.056 | <0.001 |
| | **WATER LEACH (1:20)** | | | | | | | | | | | | | | | | | | | | | | |
| | **LEACH BLANK** | | | | | | | | | | | | | | | | | | | | | | |
| **877437** | **SS01-ASH/WATER/LEACH** | | | | | | | | | | | | | | | | | | | | | | |
| | **duplicate** | | | | | | | | | | | | | | | | | | | | | | |
| **877438** | **SS02-DROSS/WATER/LEACH** | | | | | | | | | | | | | | | | | | | | | | |

Date: 16/03/2023
Analysed by: UIS Waterlab/Ricardo Kayser

# ANALYTICAL REPORT:

No unauthorised copies may be made of this report.

| | | | |
|---|---|---|---|
| To: | **GIY Hydroponics Trading as AquiScience (C.O.D)** | Date of Request: 07.02.2023 | UIS Analytical Services |
| Attention | **Ockie Scholtz** | | Analytical Chemistry |
| Order no: | **HDGSA)** | | Laboratories 4, 6 |
| Quote: | **Q-GEO-23/00285** | | Tel: (012) 665 4291 |
| | | | Fax: (012) 665 4294 |

## Certificate of analysis: 50174

Note: all results in percentage (%) or parts per million (mg/kg) unless specified otherwise

| **Lims ID** | **Sample ID** | **Si** | **Al** | **Fe** | **Ti** | **Ca** | **Mg** | **K** | **Mn** | **P** | **Cr** | **Cu** | **Pb** | **V** | **Zn** | **Ni** | **Ba** | **Co** | **Sn** | **C** | **S** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % |
| **877435** | **SS01-ASH** | 0.008 | 0.36 | 0.194 | 0.005 | 0.028 | 0.004 | 0.04 | 0.137 | 0.055 | 0.004 | 0.003 | 0.231 | 0.002 | 98.8 | 0.036 | <0.001 | <0.001 | 0.004 | 0.070 | <0.003 |
| **877435 QC** | **Duplicate** | 0.011 | 0.36 | 0.186 | 0.005 | 0.030 | 0.004 | 0.05 | 0.137 | 0.050 | 0.004 | 0.003 | 0.235 | 0.002 | 98.8 | 0.038 | <0.001 | <0.001 | 0.003 | 0.072 | <0.003 |
| **877436** | **SS02-DROSS** | 0.005 | 0.02 | 4.53 | 0.004 | 0.061 | 0.012 | <0.01 | 0.041 | 0.061 | 0.014 | 0.183 | 0.051 | 0.001 | 93.9 | 0.898 | 0.001 | 0.004 | 0.032 | 0.092 | <0.003 |
| **877436 QC** | **Duplicate** | 0.003 | 0.02 | 4.28 | 0.003 | 0.054 | 0.009 | <0.01 | 0.033 | 0.061 | 0.006 | 0.198 | 0.064 | 0.001 | 94.2 | 0.930 | 0.001 | 0.004 | 0.036 | 0.094 | <0.003 |

Note: Analysis done on sample as received before drying

Note: LOI does not include moisture

| | |
|---|---|
| Chemical elements: | Si, Al, Fe, Ti, Ca, Mg, K, Mn, P, Ba ,Pb, Cu, Cr, Zn, V, Co, Sn, Ni, C, S |
| Instrument: | ICP-OES, Leco CS230 |
| Method | Major & Minor elements in Metals by ICP-OES |

| | | | |
|---|---|---|---|
| Date: | 17.03.2023 | Date: | 2023.04.18 |
| Analyst: | MA Motsepe | Authorised : | JJ Oberholzer |

# ANALYTICAL REPORT: Total Trace Elements

No unauthorised copies may be made of this report.

|  |  |  |  |
|---|---|---|---|
| **To:** | **GIY Hydroponics Trading as AquiScience** | Date of Request: 07-02-2023 | UIS Analytical Services<br>Analytical Chemistry<br>Laboratories 4, 6<br>Tel: (012) 665 4291<br>Fax: (012) 665 4294 |
| **Attention:** | **Ockie Scholtz** |  |  |
| **Project ID:** | **Q-GEO-23/00285 (HDGSA)** |  |  |
| **Site Location:** |  |  |  |
| **Order No:** |  |  |  |

**Certificate of analysis: 50174**

Note: all results in parts per million (mg/kg) unless specified otherwise

| **Lims ID** | **Sample ID** | **Ag** | **As** | **Ba** | **Be** | **Bi** | **Cd** | **Co** | **Cr** | **Cs** | **Cu** | **Ga** | **Ge** | **Hf** | **Hg** | **Ho** | **In** | **Mn** | **Mo** | **Nb** | **Ni** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | **Total trace elements** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** |
| **877435** | **SS01-ASH** | 3.91 | 45.9 | 1.17 | <0.10 | 0.93 | 3.95 | 0.55 | 41.0 | <0.10 | 44.8 | 2.22 | 1.12 | <0.10 | <0.10 | <0.10 | <0.10 | 1186 | 3.88 | 17.4 | 401 |
| **877436** | **SS02-DROSS** | 5.47 | 2.31 | 8.30 | 0.14 | 0.29 | 2.19 | 29.1 | 142 | 0.24 | 2020 | 1.92 | 1.34 | <0.10 | 0.12 | <0.10 | <0.10 | 332 | 6.99 | 2.09 | 10165 |

| **Lims ID** | **Sample ID** | **Pb** | **Rb** | **Sb** | **Sc** | **Se** | **Sn** | **Sr** | **Ta** | **Te** | **Th** | **Tl** | **U** | **V** | **W** | **Zr** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** | **mg/kg** |
| **877435** | **SS01-ASH** | 2249 | 0.51 | 5.18 | 0.18 | 2.37 | 44.7 | 0.49 | <0.10 | <0.10 | <0.10 | 10.8 | <0.10 | 28.0 | 0.28 | 5.34 |
| **877436** | **SS02-DROSS** | 494 | 1.23 | 3.47 | 0.23 | 2.33 | 370 | 1.42 | <0.10 | <0.10 | <0.10 | 0.14 | <0.10 | 11.3 | 0.44 | 4.88 |

Chemical elements: Ag, As, Ba, Be, Bi, Cd, Co, Cr, Cs, Cu, Ga, Ge, Hf, Hg, Ho, In, Mn, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, Tl, U, V, W, Zr
Instrument: ICP-MS
Method UIS-AC-T104 Trace Elements in solid by ICP-MS (Aqua regia)

|  |  |  |  |
|---|---|---|---|
| Date: | 05-04-2023 | Date: | 18-04-2023 |
| Analysed by: | SD Masebe & V Mammburu | Authorised : | JJ Oberholzer |

BIOTOX LAB
www.biotoxsa.co.za

Company registration number: 2012/106020/07
VAT number: 4740264959

**Tests performed at: GAUTENG OFFICE:**
P.O. Box 11216, Silver Lakes, Pretoria, 0054
78 Pony Street, Tijgervallei Office Park, Block 5, Unit 2, Silver Lakes
Fax: 086 535 7368
Tel: 012 753 2192
Email: lizet@biotoxsa.co.za or marliseb@biotoxsa.co.za

ilac-MRA sanas Testing Laboratory
T0663

Toxicity Specialists

# TOXICITY TEST REPORT

## For:
GIY Hydroponics

136 Meyer Street, Loerie Park, George, 6529
ockie@shangoni.co.za

## Survey:
2023-02

## Report reference:
GIY-HDG-A-23_TOX

## Revision:
0

## Project:
Hot Dip Galvanizers

## Samples:
SS01 Ash, SS02 Dros

**Tests performed by: Praise Manyenga (Senior Analyst); Lethabo Mothupi (Junior Analyst)**
**Inputs and results verified by: Praise Manyenga (Laboratory Manager); Lethabo Mothupi (Analyst)**
**Classification (DEEEP) performed by: Lizet Swart (Quality Control Manager)**

| **Report approved by:** | **Results approved by:** | |
|---|---|---|
| | pmanyenga<br>pmanyenga (Feb 24, 2023 14:54 GMT+2) | |
| **Lizet Swart**<br>**Quality Control Manager** | **Praise Manyenga**<br>**Technical Signatory** | **Report issue date**<br>**23 February 2023** |

# Table of contents

# List of Tables

## 1. ANALYSES REQUESTED AND SAMPLE INFORMATION

Enclosed please find Test Certificate of analysis number GIY-HDG-A-23_TOX. The results relate only to the sample(s) tested. BioToxLab does not accept responsibility for any matters arising from the further use of the results. Tests marked “Not SANAS accredited” (NA or OS) in this Certificate of Analyses are not included in the SANAS Schedule of Accreditation for this Laboratory.

No part of this Certificate of Analyses may be quoted in isolation of the rest of the text without the written permission of BioToxLab. Opinions and Interpretations expressed herein are outside the scope of SANAS accreditation.

Please contact the Laboratory if further information is required.

**Table 1:** Analyses requested and description for the different samples, including sampling and delivery dates.

| Sample name | Sampling date | Sample type (water, sediment, product etc) | Sampled by | Delivery date | Delivered by | Additional comments (sample description or deviations) | Tests requested - Marked with X | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Water | | | | | Sediment | |
| | | | | | | | Screening | Definitive | *Daphnia magna* | *Poecilia reticulata* | *Allivibrio fischeri* | *Selenastrum capricornutum* | *Spirodela polyhiza* | Phyto seeds | Ostracod |
| SS01 Ash | 2023.02.08 | Sediment | GIY Hydroponics | 2023.02.08 | GIY Hydroponics | None | | X | X | X | | | X | | |
| SS02 Dros | 2023.02.09 | Sediment | GIY Hydroponics | 2023.02.10 | GIY Hydroponics | None | | X | X | X | | | X | | |

**Key:**
Screening = 100% (undiluted) sample tested only
Definitive = Series of sample dilutions tested to enhance classification accuracy and to determine safe dilution

## 2. METHODOLOGY

### Sampling and sample handling

Samples were analysed as received from the Client. The samples received from GIY Hydroponics were leached and the leachate exposed as definitives on 3 trophic levels (*Spirodela polyrhiza*, *Daphnia magna* and *Poecilia reticulata*).

### Test Conditions

All toxicity tests were conducted in environmentally controlled rooms using standard techniques.

### Quality Assurance

The BioToxLab Aquatic Toxicology Laboratory’s Policy and Quality Manual, intended to support and maintain all aspects of the Quality System, is based on the application of ISO/IEC 17025. The following Quality Assurance information can be made available on request (1) inhouse reference toxicant test data and control charts (2) Proficiency Testing Scheme (PTS) test data (3) lot and batch numbers (4) raw toxicity test data.

### Assessments

Given the limitations of substance-specific assessments, and the risk of allowing ecological toxicity hazards to go unchecked/undetected, water resource managers and scientists have for some time called for methodologies that will allow more complete assessment s of ecological toxicity hazards to be used in addition to the substance-specific approach. The National Water Act (Act no. 36 of 1998), providing for water in sufficient quantity and in sufficient quality for basic human needs and for maintenance of aquatic ecosystem function, implemented an approach known as the Direct Estimation of Ecological Effect Potential (DEEEP) protocol as a means of circumventing the shortcomings of direct toxicant monitoring. This protocol consists of a battery of tests to directly assess lethal (acute) and sub-lethal (chronic) toxicity, using test organisms from a range of trophic levels. These toxicity tests can demonstrate whether contaminants are bioavailable, it can evaluate the aggregate toxic effects of all contaminants in the medium and it can evaluate the toxicity of substances whose biological effects may not have been well characterized.

Lethal or sub-lethal toxicity testing (as applied for this assessment) is applied by exposing biota to the leachate of the samples submitted in order to determine the potential risk of such leachates to the biota/biological integrity of the receiving water bodies and the environment. A risk category is determined based on the percentage of mortalities (lethal) or inhibition (sub-lethal) of the exposed biota. It is important to note that the hazard classification is based on the standardised battery of selected test biota and therefore represents the risk/hazard towards similar biota in the receiving aquatic environment. The toxicity hazard is therefore in terms of the aquatic biotic integrity and does in no way represent toxicology towards humans or other mammals.

Physical and chemical properties as required to be performed by the standard toxicity methods are also presented in this report as supplementary data to the toxicity testing data.

Standard, internationally accepted methods and materials were applied in order to conduct lethal and sub-lethal toxicity testing.

### *Spirodela polyrhiza* sub-lethal *toxicity test* (A)

| | |
|---|---|
| BioToxLab method number: | QM7.2/TMH-15 |
| Standard method: | ISO 20227: 2017 |
| Deviation from the method: | None |
| Test endpoint: | $EC_{20}$/$EC_{50}$ |
| Exposure period: | 72-hours |
| Test chamber type: | Polystyrene plates (9x13 cm) with 48 wells (1 mL) |
| Test sample volume: | 1 mL |
| Number of replicates per sample: | 8 |
| Test temperature (24-26°C): | 25.0°C |
| Test organism species name and source: | *Spirodela polyrhiza* – Turions obtained from MicrobioTests test kit |
| Area measurement: | Image J from photograph taken of test plate |
| *Spirodela* batch number(s): | SPP 120822 |
| Steinberg medium batch number(s): | SM 170321 |
| Statistical methods used: | Microsoft Excel® spreadsheet formulated by supplier (MicroBioTests Inc., Belgium) – RegTox and Regression analysis |
| Date(s) of performance of the test(s): | 2023.02.17 |
| Uncertainty of measurement: | Available on request |
| Validity (mean growth of first fronds in cups of control column after 3 days incubation at 25°C and under 6000lux illumination ≥10mm$^2$): | 54.76 mm$^2$ |

## *Daphnia magna* lethality toxicity test (A)

| | |
|---|---|
| BioToxLab method number: | QM7.2/TMH-03 |
| Standard method: | SANS 6341: 2015 |
| Deviation from the method: | None |
| Test endpoint: | $LC_{10}$/$LC_{50}$ |
| Exposure period: | 24- and 48-hours |
| Test chamber type: | Polycarbonate test plates (6 rinsing wells and 24 testing wells) |
| Test sample volume: | 25 mL |
| Number of replicates per sample: | 4 |
| Number of test organisms per chamber: | 5 |
| Test temperature (20-22°C): | 21.0°C |
| Test organism species name, age & source: | *Daphnia magna* – ephippia obtained from MicroBiotests, <24h old |
| Feeding frequency during testing: | None |
| Ephippia batch number(s): | DM121022 |
| ISO media batch number(s): | ISO080422 |
| Statistical methods used: | Microsoft Excel® |
| Date(s) of performance of the test(s): | 2023.02.20 |
| Uncertainty of measurement: | Available on request |
| Validity criteria (control mortality≤10%): | 0% |

## *Poecilia reticulata* lethality toxicity test (A)

| | |
|---|---|
| BioToxLab method number: | QM7.2/TMH-04 |
| Standard method: | SANS 7346-1: 2013 |
| Deviation from the method: | None |
| Test endpoint: | $LC_{10}$/$LC_{50}$ |
| Exposure period: | 96-hours |
| Test chamber type: | 250 mL disposable polystyrene cups |
| Test sample volume: | 200 mL |
| Number of replicates per sample: | 2 |
| Number of test organisms per chamber: | 6 |
| Test temperature (22-24°C): | 23.8°C – 24.0°C |
| Test organism species name, age & source: | *Poecilia reticulata* – 7-21 days old. Obtained from external stock |
| Feeding frequency during testing: | None |
| ISO media batch number(s): | ISO080422 |
| Statistical methods used: | Microsoft Excel® |
| Date(s) of performance of the test(s): | 2023.02.16 |
| Uncertainty of measurement: | Available on request |
| Validity criteria (control mortality≤10%): | 0% |

## Physical and chemical properties

| Parameter | BioToxLab Method number | Test temperature (25°C±3°C) | Instrument | Batch number(s) | Date(s) of test(s) |
|---|---|---|---|---|---|
| pH (A) | QM7.2/TMC-05 | 25.2°C | HQ440d | pH1.67: C02929<br>pH4: A2076A<br>pH7: A1235R<br>pH10: A2102 | 2023.02.15 |
| EC (A) | QM7.2/TMC-06 | 25.2°C | HQ440d | 1413µS/m: A2214 | 2023.02.15 |
| Dissolved oxygen (NA) | QM7.2/TMC-07 | 25.2°C | HQ440d | N/A | 2023.02.15 |
| Uncertainty of measurement for accredited (A) methods available on request | | | | | |

## 3. HAZARD CLASSIFICATION METHODOLOGY

The toxicity unit (TU) for each test performed is calculated as 100% (full strength effluent expressed as percentage) divided by the effective concentration or $LC_{50}$ expressed as percentage sample dilution (e.g. *Daphnia magna* and *Poecilia reticulata* lethal toxicity tests) and $EC_{50}$ (e.g. *Spirodela polyrhiza* growth inhibition test) (Tonkes & Baltus, 1997) (Table 2). If there is insufficient toxicity in a sample to allow for the determination of an $EC_{50}$/$LC_{50}$ value, then a toxicity unit of <1 will be assigned to the sample.

**Table 2:** Toxicity Units (Tonkes and Baltus, 1997)

| Toxicity Unit | Conclusion/Description |
|---|---|
| <1 | Limited to no toxicity |
| 1 – 2 | Negligibly toxic |
| 2 – 10 | Mildly toxic |
| 10 – 100 | Acutely toxic |
| > 100 | Highly toxic |

A risk/hazard category is determined by using a hazard classification system developed by Persoone *et al.* (2003) whereby one can classify sites using the toxicity data of the non-diluted samples. The percentage effect (PE) of toxicity (mortalities, growth inhibition) is used to rank the sample into one of five classes (Table 3 – effluent/waste/leachate samples) based on the highest toxic response obtained in at least one of the tests applied.

**Table 3:** Hazard classification system for effluent/waste samples

| Class | Symbol | Hazard rating | PE | Percentage effect |
|---|---|---|---|---|
| I | ☺ | No lethal/sub-lethal hazard | ≤10/20% | None of the tests show a toxic effect (i.e. an effect value that is significantly higher than that noted in the controls) |
| II | ☹ | Slight lethal/sub-lethal hazard | 10/20%≤PE<50% | The effect percentage observed in at least one toxicity test is significantly higher than that in the control, but is below 50% (< 1 TU) |
| III | ☠ | Lethal/sub-lethal hazard | 50%≤PE<100% | The $L(E)C_{50}$ is reached or exceeded in at least one test, but in the 10-fold dilution of the sample, the effect is less than 50% (= 1-10 TU) |
| IV | ☠☠ | High lethal/sub-lethal hazard | PE 100% in at least one test | The $L(E)C_{50}$ is reached in the 10-fold dilution for at least one test but not in the 100-fold dilution (=10-100 TU) |
| V | ☠☠☠ | Very high lethal/ sub-lethal hazard | PE 100% in all tests | The $L(E)C_{50}$ is reached in the 100-fold dilution for at least one test (≥ 100 TU) |

Each sample is furthermore weighted (Table 4) according to its relative toxicity level (out of 100%). Higher values indicate that more of the individual tests indicated toxicity within a specific class.

**Table 4:** Weight score allocation for each test type (Persoone *et al.* (2003))

| Score | Category |
|---|---|
| 0 | No significant toxicity effect |
| 1 | Significant toxicity effect < PE50 |
| 2 | Toxicity effect >PE50 but <PE100 |
| 3 | The PE100 is reached |

Class weight score calculated as follows:
Class weight score = (∑ all test scores)/n) where n is the number of tests performed
Class weight score % = (class score) / (maximum class weight score) x 100

EP (Percentage effect) = an effect measured either as mortality or inhibition (depending on the type of test). A >10% effect is regarded as slight lethal toxicity for *Daphnia* and *Poecilia,* while a >20% effect is regarded as slight sub-lethal toxicity for *Spirodela*. A 50% effect is regarded as a lethal/sub-lethal toxicity for all the tests (*Daphnia*, *Poecilia* and *Spirodela*)

The toxicity hazard for each dilution level used to assess the hazard and perform calculations and classifications are presented in Table 5 in order to asses/review data trends and are done according to the following scale:

**Table 5:** Hazard class per dilution level scale

| Scale | Description |
|---|---|
| 0-≤10% (*Daphnia, Poecilia*)<br>0-≤20% (*Spirodela*) | Not toxic |
| 10-<50 (*Daphnia, Poecilia*)<br>20-<50 (*Spirodela*) | Slightly toxic |
| 50-<100 (*Daphnia, Poecilia, Spirodela*) | Toxic |
| ≥100 (*Daphnia, Poecilia, Spirodela*) | Highly toxic |

## 4. RESULTS AND HAZARD CLASSIFICATION DATA

**Table 6:** Hazard classification of water samples

| Site/ sample | Ducweed (A) *Spirodela polyrhiza* | | | Crustacea (A) *Daphnia magna* | | | Vertebrates (A) *Poecilia reticulata* | | | Weight % |
|---|---|---|---|---|---|---|---|---|---|---|
| | % effect | TU | Test score | % effect | TU | Test score | % effect | TU | Test score | |
| SS01 Ash | -93.08 | >100 | 4 | -100 | >100 | 4 | -100 | >100 | 4 | 100 |
| SS02 Dros | -72.65 | >100 | 4 | -5 | <1 | 0 | -8.33 | <1* | 1 | 42 |

TUs not applicable to screening testing (N/A)

* Although no significant effect was noted on the 100% sample, a slight effect was noted on the 1% dilution of the sample

**Table 7:** Hazard classification of water sample dilutions (as per Table 5 methodology)

| Dilution level | Sample name | Toxicity hazard | Sample name | Toxicity hazard | Sample name | Toxicity hazard |
|---|---|---|---|---|---|---|
| 100% | *D. magna* SS01 Ash | Highly toxic | *P. reticulata* SS01 Ash | Highly toxic | *S. polyrhiza* SS01 Ash | Toxic |
| 50% | | Highly toxic | | Highly toxic | | Toxic |
| 25% | | Highly toxic | | Highly toxic | | Toxic |
| 10% | | Highly toxic | | Highly toxic | | Toxic |
| 1% | | Highly toxic | | Toxic | | Toxic |
| 100% | *D. magna* SS02 Dros | Not toxic | *P. reticulata* SS02 Dros | Not toxic | *S. polyrhiza* SS02 Dros | Toxic |
| 50% | | Not toxic | | Not toxic | | Toxic |
| 25% | | Not toxic | | Not toxic | | Toxic |
| 10% | | Not toxic | | Not toxic | | Toxic |
| 1% | | Not toxic | | Slightly toxic | | Toxic |

**Table 8:** Site hazard classification of water samples

| | Results | SS01 Ash | SS02 Dros |
|---|---|---|---|
| **Water quality** | Test date yy/mm/dd | 2023.02.15 | 2023.02.15 |
| | pH @ 25°C (A) | 6.3 | 7.4 |
| | EC (Electrical conductivity) (mS/m) @ 25°C (A) | 1.4 | 1.9 |
| | Dissolved oxygen (mg/l) (NA) | 7.3 | 5.9 |
| ***S. polyrhiza* (duckweed) (A)** | Test started on yy/mm/dd | 2023.02.17 | 2023.02.17 |
| | %72hour inhibition (-) / stimulation (+) (%) | **-93** | **-73** |
| | EC/LC20 (72hours) | **n.c.** | **n.c.** |
| | EC/LC50 (72hours) | **n.c.** | **n.c.** |
| | Toxicity unit (TU) / Description | >100 | >100 |
| ***D. magna* (waterflea) (A)** | Test started on yy/mm/dd | 2023.02.20 | 2023.02.20 |
| | %48hour mortality rate (-%) | **-100** | **-5** |
| | EC/LC10 (48hours) | **n.c.** | **n.r.** |
| | EC/LC50 (48hours) | **n.c.** | **n.r.** |
| | Toxicity unit (TU) / Description | >100 | <1 |
| ***P. reticulata* (guppy) (A)** | Test started on yy/mm/dd | 2023.02.16 | 2023.02.16 |
| | %96hour mortality rate (-%) | **-100** | **-8** |
| | EC/LC10 (96hours) | **n.c.** | **n.c.** |
| | EC/LC50 (96hours) | **n.c.** | **n.r.** |
| | Toxicity unit (TU) / Description | >100 | <1 |
| | ***Estimated safe dilution factor (%) [for definitive testing only]*** | **<1** | **<1** |
| | **Overall classification - Hazard class***** | Class V - Very high lethal/sub-lethal hazard | Class V - Very high lethal/sub-lethal hazard |
| | Weight (%) | 100 | 42 |

**Key:**

**%** = for definitive testing, only the 100% concentration (undiluted) sample mortality/inhibition/stimulation is reflected by this summary table. The dilution series results are considered for EC/LC values and Toxicity unit determinations

**n.r.** = not relevant, i.e. the 100% concentration caused less than 10/20/50% (effective concentration) mortalities or inhibition

**n.c.** = not calculable, although the 100% concentration led to more than 10/20/50% mortalities/inhibtion or the 100% sample showed no significant effects, the 10/20/50% mortality/inhition rate was exceeded throughout the test

***** = The overall hazard classification takes into account the full battery of tests and is not based on a single test result. Note that the overall hazard classification is expressed as both lethal (*Daphnia* & *Poecilia*) and sub-lethal (*Spirodela*) levels of toxicity

**Weight (%)** = relative toxicity levels (out of 100%), higher values indicate that more of the individual tests indicated toxicity within a specific class

site/sample name shaded in orange = definitive test

| Site | Hazard classification | | | Percentage Effect |
|---|---|---|---|---|
| SS01 Ash | V | ☠☠☠ | Very high lethal/sub-lethal hazard | The $L(E)C_{50}$ is reached in the 100-fold dilution for at least one test (≥ 100 TU) |
| SS02 Dros | V | ☠☠☠ | Very high lethal/sub-lethal hazard | The $L(E)C_{50}$ is reached in the 100-fold dilution for at least one test (≥ 100 TU) |

The leachates of both samples were allocated a Hazard Class V (very high lethal/sub-lethal environmental toxicity hazard). For sample SS01 Ash, the 50% effect level was exceeded throughout the test on all 3 trophic levels applied during testing. For sample SS02 Dros, the 50% effect level was exceeded throughout the duckweed (*S. polyrhiza*) test (sub-lethal) and although no significant effect was noted following the vertebrate (*P. reticulata*) test, slight mortalities were noted on the lowest dilution of the leachate sample (1% dilution).

## 5. COMMENTS

Two ash & slag/dros samples were delivered to the BioToxLab office on 2023.02.08. The samples were leached and the leachate tested as per the request sheet. The pH levels of the leachate samples were 6.29 (SS01 Ash) and 7.44 (SS02 Dros) which are within the acceptable range (pH 6-9) in which pH can be excluded as a driving factor for toxicity (USEPA, 1996). The conductivities (ECs) of the leachate samples were 1.4 mS/m (SS01 Ash) and 1.9 mS/m (SS02 Dros). A dissolved oxygen (DO) concentration above 4 mg/L is required for aquatic organisms (USEPA, 1996) to survive. The DO levels for the 2 leachate samples were 7.27 mg/L (SS01 Ash) and 5.94 mg/L (SS02 Dros).

Any queries regarding the results can be lodged with Lizet Swart within 14 days from the date of receiving this report after which the samples will be discarded. It is not advised to use these samples for any retesting other than range confirmation of chemical parameters – re-sampling must be done in the case of any queries relating to the results associated with the samples.

## 6. REFERENCES

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INTERNATIONAL STANDARD ISO 20227:2017. Determination of the growth inhibition effects of waste waters, natural waters and chemicals on the duckweed *Spirodela polyrhiza* – Method using a stock culture independent microbiotest

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SOUTH AFRICAN NATIONAL STANDARD, (SANS), ISO/IEC 17025:2017. General requirements for the competence of testing and calibration laboratories. 3rd Edition. South African Bureau of Standards, Pretoria.

SOUTH AFRICAN NATIONAL STANDARD, SANS 6341:2015. "Water quality – Determination of the inhibition of the mobility of *Daphnia magna* Straus (*Cladocera, Crustacea*) – Acute toxicity test.

SOUTH AFRICAN NATIONAL STANDARD, SANS 7346-1:2013. "Water quality – Determination of the acute lethal toxicity of substances to a freshwater fish [*Brachydanio rerio* Hamilton-Buchanan (Teleostei, Cyrinidae) Part 1: Static method – also applicable to *Poecilia reticulata* (Teleostei, Poeciliidae)

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## END OF REPORT

# GIY-HDG-A-23_TOX (final)

Final Audit Report 2023-02-24

| | |
|---|---|
| Created: | 2023-02-24 |
| By: | Lizet Moore (lizet@biotoxsa.co.za) |
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# APPENDIX C

## Safety Data Sheets

Zinc-Dross

Zn-Ash

$ZnSO_4$

ZnO

HOT DIP
GALVANIZERS
ASSOCIATION
SOUTHERN AFRICA

# MATERIAL SAFETY DATA SHEET (MSDS)

## ZINC DROSS

*(EC) No 1272/2008EC*

## *Section 1 – Identification*

**1(a) Product Identifier:** Zinc Dross
**1(b) Other Means of Identification:** N/A
**1(c) Recommended use of the chemical and restrictions on use:** Secondary / by-product material.
**1(d) Name, Address, and Telephone Number:**
Hot Dip Galvanizers Association Southern Africa
3 Riley Road
Bedfordview, 2006
Gauteng
SOUTH AFRICA
011 456 7960
**1(e) Emergency Phone Number:** Robin Clarke 082 902 5119

## *Section 2 – Hazard(s) Identification*

**2(a) Classification of the substance or mixture:**
Zinc Dross is considered a hazardous material according to the criteria of Regulation (EC) No 1272/2008.
**Class:** Repr.
**Category:** Category 1A
**Hazard Statements:** H360D – May damage unborn child
**2(b) Label Elements:**

| Hazard Symbol | Hazard Classification | Signal Word | Hazard Statement(s) |
|---|---|---|---|
|  | H360D | Danger | May damage unborn child |

**Precautionary Statement(s):**
P202: Do not handle until all safety precautions have been read and understood.
P280: Wear protective gloves and protective clothing.
P308+P313: If exposed or concerned: Get medical advice/attention.
P405: Store locked up.

**2(c) Hazards not Otherwise Classified:** None Known
**2(d) Unknown Acute Toxicity Statement (Mixture):** None Known

## *Section 3 – Composition/Information on Ingredients*

**Chemical Name, Common Name (Synonyms), CAS Number and Other Identifiers, and Concentration:**

| Chemical Name | CAS Number | Classification according to CLP | % weight |
|---|---|---|---|
| Zinc | 7440-66-6 | H410 Very toxic to aquatic life with long lasting effectts | 90-94.4 |

| | | | |
|---|---|---|---|
| Aluminium | 7429-90-5 | H228 Flam. Sol. 1 | 0.005 – 0.01 |
| Cadmium | 7440-43-9 | H330 Fatal if inhaled H341 - Suspected of causing genetic defects H350 - May cause cancer H361fd - Suspected of damaging fertility. Suspected of damaging the unborn child H372 - Causes damage to organs through prolonged or repeated exposure H410 - Very toxic to aquatic life with long lasting effects | ≤0.005 |
| Chromium | 7440-47-3 | Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008 | 0.01-0.011 |
| Copper | 7440-50-8 | Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008 | ≤0.01 |
| Iron | 7439-89-6 | H228 Flammable solid. | 1.64-3.19 |
| Magnesium | 7439-95-4 | H250 - Catches fire spontaneously if exposed to air H260 - In contact with water releases flammable gases which may ignite spontaneously | 0.005-0.008 |
| Manganese | 7439-96-5 | H228 Flammable solid. | ≤0.01 |
| Nickle | 7440-02-0 | H317 May cause an allergic skin reaction H351 Suspected of causing cancer H372 Causes damage to organs through prolonged or repeated exposure H412 Harmful to aquatic life with long lasting effects | 0.01-0.27 |
| Lead | 7439-92-1 | H360 May damage fertility or the unborn child. H360FD May damage fertility. May damage the unborn child. H362 May cause harm to breast-fed children. H372 Causes damage to organs through prolonged or repeated exposure | 0.10-1.33 |
| Silicon | 7440-21-3 | H228 Flammable solid. | 0.01-0.02 |
| Tin | 7440-31-5 | Not a hazardous substance or mixture according to Regulation (EC) No. 1272/2008 | ≤0.005 |

**EC**- European Community **CAS**- Chemical Abstract Service

## *Section 4 – First-aid Measures*

**4(a) Description of Necessary Measures:**

- **Inhalation:** Remove person to fresh air and keep comfortable for breathing. Get medical advice/attention if you feel unwell.
- **Eye Contact:** Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical advice/attention if you feel unwell.
- **Skin Contact:** If skin irritation occurs: Get medical advice/attention.
- **Ingestion:** Get medical advice/attention if you feel unwell.

**4(b) Most Important Symptoms/Effects, Acute and Delayed (Chronic):**

**Acute effects:**

- **Inhalation:** Excessive exposure to high concentrations of dust may cause irritation to the mucous membranes of the upper respiratory tract.
- **Eye:** Excessive exposure to high concentrations of dust may cause irritation to the eyes.

## *Section 4 – First-aid Measures (continued)*

**Acute effects (continued):**

- **Skin:** Skin contact with dusts may cause irritation- possibly leading to dermatitis. Skin contact with metallic fumes and dusts may cause physical abrasion.
- **Ingestion:** Ingestion of harmful amounts of this product as distributed is unlikely due to its solid insoluble form. Ingestion of dust may cause nausea or vomiting.

**Chronic Effects:**

Long-term inhalation exposure to high concentrations (over-exposure) of agents that produce lung disorders may act synergistically with inhalation of oxides, vapours or dusts of this product to cause toxic effects.

**4(c) Immediate Medical Attention and Special Treatment:** Treat symptomatically.

## *Section 5 – Fire-fighting Measures*

**5(a) Suitable (and Unsuitable) Extinguishing Media:** Use extinguishers appropriate for surrounding materials.

**5(b) Specific Hazards Arising from the Chemical:** Not applicable for solid product.

**5(c) Special Protective Equipment and Precautions for Fire-fighters:** Self-contained NIOSH approved respiratory protection and full protective clothing should be worn when fumes and/or smoke from fire are present. Heat and flames cause emittance of acrid smoke and fumes. Do not release runoff from fire control methods to sewers or waterways. Firefighters should wear full face-piece self-contained breathing apparatus and chemical protective clothing with thermal protection. Direct water stream will scatter and spread flames and, therefore, should not be used.

## *Section 6 - Accidental Release Measures*

**6(a) Personal Precautions, Protective Equipment and Emergency Procedures:** Not applicable in solid state. For spills involving finely divided particles, clean-up personnel should be protected against contact with eyes and skin. If material is in a dry state, avoid inhalation of dust. Fine, dry material should be removed by vacuuming or wet sweeping methods to prevent spreading of dust. Avoid using compressed air. Do not release into sewers or waterways. Collect material in appropriate, labelled containers for recovery or disposal in accordance with Federal, Provincial/State, and Local regulations.

**6(b) Methods and Materials for Containment and Clean Up:** Collect material in appropriate, labelled containers for recovery or disposal in accordance with Federal, Provincial/State, and Local regulations. Follow applicable OSHA regulations (29 CFR 1910.120) and all other pertinent Provincial/State and Federal requirements.

## *Section 7 - Handling and Storage*

**7(a) Precautions for Safe Handling:** Operations with the potential for generating high concentrations of airborne particulates should be evaluated and controlled as necessary. Practice good housekeeping. Avoid breathing metal fumes and/or dust.

**7(b) Conditions for Safe Storage, Including any Incompatibilities:** Avoid storage with strong acids

## *Section 8 - Exposure Controls / Personal Protection*

**8(a) Occupational Exposure Limits (OELs):**.The following exposure limits are offered as reference, for an experience industrial hygienist to review.

| **Ingredients** | **OSHA PEL [1]** | **ACGIH TLV [2]** | **NIOSH REL [3]** | **MOL [4]** |
|---|---|---|---|---|
| Zinc | 5.0 mg/m$^3$ (as zinc oxide fume)<br>15 mg/m$^3$ (as total dust)<br>5.0 mg/m$^3$(as respirable fraction) | 2.0 mg/m$^3$ (as zinc oxide) | 10 mg/m$^3$ (as total dust)<br>5.0 mg/m$^3$ (as respirable dust) | 2.0 mg/m$^3$ (as zinc oxide, respirable fraction)<br>"STEL" 10mg/m$^3$ (as respirable fraction) |
| Aluminium | 15 mg/m$^3$ (as total dust, PNOR[5])<br>5.0 mg/m$^3$ (as respirable fraction, PNOR) | 1.0 mg/m (as respirable fraction) | 10 mg/m (as total dust)<br>5.0 mg/m (as respirable dust) | 1.0 mg/m$^3$ (as respirable fraction) |

## Section 8 - Exposure Controls / Personal Protection (continued)

**8(b) Appropriate Engineering Controls:** Local exhaust ventilation should be used to control the emission of air contaminants. General dilution ventilation may assist with the reduction of air contaminant concentrations. Emergency eye wash stations and deluge safety showers should be available in the work area.

**8(c) Individual Protection Measures:**

- **Respiratory Protection:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, use only a NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. Concentration in air of the various contaminants determines the extent of respiratory protection needed. Half-face, negative-pressure, air-purifying respirator equipped with P100 filter is acceptable for concentrations up to 10 times the exposure limit. Full-face, negative-pressure, air-purifying respirator equipped with P100 filter is acceptable for concentrations up to 50 times the exposure limit. Protection by air-purifying negative pressure and powered air respirators is limited. Use a positive-pressure-demand, full-face, supplied air respirator or self contained breathing apparatus (SCBA) for concentrations above 50 times the exposure limit. If exposure is above the IDLH (immediately dangerous to life or health) for any of the constituents, or there is a possibility of an uncontrolled release or exposure levels are unknown, then use a positive demand, full-face, supplied air respirator with escape bottle or SCBA.

**Warning!** Air-purifying respirators both negative-pressure, and powered-air do not protect workers in oxygen-deficient atmospheres.

- **Eyes**: Wear appropriate eye protection to prevent eye contact. For operations, which result in elevating the temperature of the product to or above its melting point or result in the generation of airborne particulates, use safety glasses to prevent eye contact. Contact lenses should not be worn where industrial exposures to this material are likely.
- **Skin**: Wear appropriate personal protective clothing to prevent skin contact. For operations, which result in elevating the temperature of the product to or above its melting point or result in the generation of airborne particulates, use protective clothing, and gloves to prevent skin contact. Protective gloves should be worn as required for burning or handling operations.
- **Other protective equipment:** An eyewash fountain and deluge shower should be readily available in the work area.
-

## Section 9 - Physical and Chemical Properties

**(a) Appearance (physical state, color, etc.):** Silver/grey, Solid (Metal)
**(b) Odour:** Odourless
**(c) pH :** ND
**(d) Relative Density** : 7.1 g/ml
**(e) Melting Point/Freezing Point:** 420°C (788°F)
**(f) Initial Boiling Point and Boiling Range:** 908°C (1666.4°F)
**(g) Flash Point:** NA
**(h) Decomposition Temperature:** 600°C
**(i) Flammability (solid, gas):** Non-flammable, non-combustible
**(j) Solubility(ies):** ): Insoluble in cold water

**NA -** Not Applicable **ND -** Not Determined for product as a whole

## Section 10 - Stability and Reactivity

**10(a) Reactivity:** Not Determined (ND)
**10(b) Chemical Stability:** Zinc Dross is stable under normal storage and handling conditions.
**10(c) Possibility of Hazardous Reaction:** None Known
**10(d) Conditions to Avoid:** Storage with strong acids or calcium hypochlorite.
**10(e) Incompatible Materials:** Will react with strong acids to form hydrogen.
**10(f) Hazardous Decomposition Products:** Thermal oxidative decomposition can produce toxic fumes as well as other elements.

## Section 11 - Toxicological Information

**Information on Toxicological Effects:** The following toxicity data has been determined for **Zinc Dross** by using the information available for its components applied to the guidance on the preparation of an SDS under the GHS requirements of OSHA and the EU CPL:

| Hazard Classification | Hazard Category | | Hazard Symbols | Signal Word | Hazard Statement |
|---|---|---|---|---|---|
| | EU | OSHA | | | |
| **STOT Following Repeated Exposure** (covers Categories 1 and 2) | NR | 2[j] |  | **Warning** | May cause damage to lungs through prolonged or repeated exposure. |

The following health hazard information is provided regardless to classification criteria and is based on the individual component(s):

**Acute Effects by Component:**

- **ZINC:** Not Reported/ Not Classified
- **ALUMINUM:** Not Reported/ Not Classified
- **ZINC:** Zinc Residue is a low health risk by inhalation and should be treated as a nuisance dust. Inhalation of zinc oxide fumes may cause metal fume fever, which is characterized by flu-like symptoms with metallic taste, fever, chills, cough, weakness, chest pain, muscle pain and increased white blood cell count.
- **ALUMINUM**: Chronic inhalation of finely divided powder has been reported to cause pulmonary fibrosis and emphysema. Repeated skin contact has been associated with bleeding into the tissue, delayed hypersensitivity and granulomas. Chronic exposure to aluminium flake has been reported to cause pneumoconiosis in workers. Repeat oral exposure to aluminium results in decrements in neurobehavioral function and development.

## Section 12 - Ecological Information

**12(a) Ecotoxicity (aquatic & terrestrial):** No data available for the product, **Zinc Dross** as a whole. However, individual components of the product have been found to be toxic to the environment. Dusts may migrate into soil and groundwater and be ingested by wildlife as follows: ¬ **Zinc:** EU RAR lists as Category 1 Very toxic to aquatic life with long lasting effects.
**12(b) Persistence & Degradability**: No Data Available
**12(c) Bio accumulative Potential**: No Data Available
**12(d) Mobility (in soil)**: No Data Available
**12(e) Other Adverse Effects:** None Known

**Additional Information:**
**Hazard Category:** Category 1 **Signal Word:** Warning

**Hazard Symbol:**

**Hazard Statement:** Very Toxic to aquatic life with long lasting effects.

## Section 13 - Disposal Considerations

**Disposal:**

Dispose of in accordance with Local, Provincial/State, Federal and International regulations. Observe safe handling precautions.

**Container Cleaning and Disposal:**

Follow Local, Provincial/State, Federal and international regulations. Observe safe handling precautions.

## Section 14 - Transport Information

**Department of Transportation (DOT)** does not regulate **Zinc Dross** as a hazardous material

**International Maritime Dangerous Goods (IMDG) and the Regulations Concerning the International Carriage of Dangerous Goods by Rail (RID)** classification, packaging and shipping requirements follow the US DOT Hazardous Materials Regulation.

**Regulations Concerning the International Carriage of Dangerous Goods by Road (ADR)** does not regulate **Zinc Dross** as a hazardous material.

**International Air Transport Association (IATA)** does not regulate **Zinc Dross** as a hazardous material.

**Zinc Dross** does not have a **Transport Dangerous Goods (TDG)** classification.

## Section 15 - Regulatory Information

The product, **Zinc Dross** as a whole is not listed. However, individual components of the product are listed refer to Section 8.

| CAS # | Chemical Name | Percent by Weight |
|---|---|---|
| 7440-66-6 | Zinc | 98 max |

## Section 16 - Other Information

**Disclaimer:**

The information contained in this Safety Data Sheet is taken from sources and/or based upon data believed to be reliable as of the date of issue.

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Revision: 01/September 2019

# MATERIAL SAFETY DATA SHEET (MSDS)

## ZINC ASH

### *Regulation (EC) No 1272/2008EC*

## *Section 1 – Identification*

**1(a) Product Identifier:** Zinc Ash

**1(b) Other Means of Identification:** N/A

**1(c) Recommended use of the chemical and restrictions on use:** Secondary / by-product material.

**1(d) Name, Address, and Telephone Number:**
Hot Dip Galvanizers Association Southern Africa
3 Riley Road
Bedfordview, 2006
Gauteng
SOUTH AFRICA
011 456 7960

**1(e) Emergency Phone Number:** Robin Clarke 082 902 5119

## *Section 2 – Hazard(s) Identification*

**2(a) Classification of the substance or mixture:**
Zinc Ash is considered a Highly Flammable material on contact with moist air according to the criteria of Regulation (EC) No 1272/2008.
**Class:** Flammable
**Category:** Category 1

**Hazard Statements:**
**2(b) Label Elements:**

| Hazard Symbol | Hazard Classification | Signal Word | Hazard Statement(s) |
|---|---|---|---|
|  | H250 | Danger | Catches fire spontaneously if exposed to air at elevated temperatures. |

**Precautionary Statement(s):**
P202: Do not handle until all safety precautions have been read and understood.
P280: Wear protective gloves and protective clothing.
P223: Do not allow contact with water.
P233: Protect from moisture.

**2(c) Hazards not Otherwise Classified:** None Known

**2(d) Unknown Acute Toxicity Statement (Mixture):** None Known

## *Section 3 – Composition/Information on Ingredients*

**Chemical Name, Common Name (Synonyms), CAS Number and Other Identifiers, and Concentration:**

| Chemical Name | CAS Number | Classification according to CLP | % weight |
|---|---|---|---|
| Zinc | 7440-66-6 | H260 Contact with water liberates flammable gases. | 69.6 – 87.5 |

**EC**- European Community **CAS**- Chemical Abstract Service

## *Section 4 – First-aid Measures*

| | |
|---|---|
| **- Inhalation:** | Remove victim from exposure to fresh air.<br>If feeling unwell, immediately seek medical attention. |
| **- Eye contact:** | Rinse immediately with clean water for at least 15 minutes occasionally lifting the upper and lower eyelids. Seek medical attention. |
| **- Ingestion:** | If victim is conscious and alert, give 2-4 cup fills of milk or water. Never give anything by mouth to an unconscious person. Get medical aid immediately.<br>If contact with skin, rinse with plenty of soap and water. Remove contaminated clothing. |
| **Protection of rescue personnel:** | Avoid all unnecessary exposure. Use appropriate protection. (see Section 9). |

## *Section 5 – Fire-fighting Measures*

**General Information:** As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion. Water Reactive. Material will react with water and may release a flammable and/or toxic gas. Use water spray to keep fire-exposed containers cool. Containers may explode in the heat of a fire. May ignite or explode on contact with steam or moist air.

**Flammability:** Flammable
**Flash point:** Not Available
**Extinguishing media:** Use dry sand or earth to smother fire. Do NOT use water.
Do NOT get water inside containers. Contact professional fire-fighters.
**Protection of fire-fighters:** Use breathing apparatus (self-contained breathing apparatus with full face shield).

## *Section 6 - Accidental Release Measures*

**6(a) Personal Precautions, Protective Equipment, Environmental Precautions and Emergency Procedures:**
Wear suitable gloves and eye/face protection as indicated in Section 8. Avoid dust creation.
Do not let product enter drains, sewage system, ground water.

**6(b) Methods and Materials for Containment and Clean Up:** Clean up spills immediately, observing precautions in the Protective Equipment section. Sweep up or absorb material, then place into a suitable clean, dry, closed container for disposal. Avoid generating dusty conditions. Remove all sources of ignition. Use a spark-proof tool. Provide ventilation. Do not expose spill to water.

## *Section 7 - Handling and Storage*

**7(a) Precautions for Safe Handling:** Store in cool dry place. Practice good housekeeping. Avoid making and breathing dust. Keep away from water. Avoid ingestion and inhalation. Wash thoroughly after handling.

**7(b) Conditions for Safe Storage, Including any Incompatibilities:** Use only UN approved types of packaging, water tight.

## *Section 8 - Exposure Controls / Personal Protection*

**8(a) Respiratory protection:** A respiratory protection program that meets European Standard EN 149 must be followed whenever workplace conditions warrant a respirator's use.
Follow the respirator regulations found in 29 CFR 1910.134 or European Standard EN 149.
Always use a NIOSH or European Standard EN 149 approved respirator when necessary.

**8(b) Hand and Skin protection:** Appropriate gloves and clothes to prevent skin exposure.

**8(c) Eye protection:** Chemical goggles or safety glasses.

**8(d) Engineering measures:** Use explosion-proof ventilation equipment. Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits.

## *Section 9 - Physical and Chemical Properties*

**(a) Appearance (physical state, colour, etc.):** Silver/grey, Powder

**(b) Odour:** Odourless

**(c) pH :** ND

**(d) Specific Gravity** : 7.14g/cm$^3$

**(j) Solubility(ies):** Low

**ND -** Not Determined for product as a whole

## *Section 10 - Stability and Reactivity*

| | |
|---|---|
| **Stability:** | Stable in dry air.<br>Combines vigorously or explosively with water. |
| **Conditions to Avoid:** | Incompatible materials, ignition sources, excess heat, strong oxidants, exposure to moist air or water, mechanical shock. |
| **Incompatibilities:** | Halogenated agents, strong oxidizing agents, alkali hydroxides, chlorinated solvents, strong acids, strong bases. |
| **Hazardous combustion or Decomposition Products:** | Irritating and toxic fumes and gases, toxic fumes of zinc oxide. |

## *Section 11 - Toxicological Information*

| | |
|---|---|
| **Acute effects:** | |
| **- Inhalation:** | n/a |
| **- Dermal:** | Moderate irritation to rabbits, mice and guinea pigs with 1% solution applied for 5 days. |
| **- Ingestion:** | 50 mg/3 times per day caused gastrointestinal problems. |
| **Eyes irritation (rabbit):** | 420 ug – moderate irritation. |
| **Chronic toxicity:** | n/a |
| **Sensitization:** | Contact with skin causes irritation. |
| **Carcinogenicity:** | NTP: No IARC: No Z List: No OHA Reg: No |
| **Mutagenicity:** | In vitro and in vivo test of short-term genotoxicity : no evidence of genotoxicity. |
| **Reproductive toxicity:** | No experimental or epidemiological evidence of reproduction toxicity. |

## *Section 12 - Ecological Information*

| | |
|---|---|
| **Persistence and degradability:** | Not applicable. |
| **Bioaccumulative potential:** | Not applicable. |
| **WGK (Germany):** | 2 |
| **Ecotoxicity:** | EC50 (Selenastrum capricornutum, 72 H): 170 µg ZnO/l (LISEC 1997) |
| **Mobility:** | Not applicable |

## *Section 13 - Disposal Considerations*

**Disposal:**

Dispose of in accordance with Local, Provincial/State, Federal and International regulations. Observe safe handling precautions. Zinc Ash should be recovered for recycling.

| | |
|---|---|
| **Waste of residues:** | This material and its container must be disposed of as hazardous waste. Because of possible pollution, remove as industrial waste or hazardous waste. Avoid release to the environment. Refer to special instructions/safety data sheets. |
| **Contaminated packaging:** | Keep waste packaging separate. |

## Section 14 - Transport Information

**Hazard Labels:**

4.3

| | |
|---|---|
| **Emergency Code:** | **4Y** |
| **Hazard Symbol** | F |
| **UN - No:** | UN 1435 |
| **ADR/IMO-IMDG:** | 4.3, |
| **Shipping Name:** | Zinc Ashes |
| **Packaging Group:** | II |
| **EMS Code:** | F-G, S-O |

## Section 15 - Regulatory Information

| CAS # | Chemical Name | Classification according to CLP | Percent by Weight |
|---|---|---|---|
| 7440-66-6 | Zinc | H250 Catches fire spontaneously if exposed to air | 92.7 max |

## Section 16 - Other Information

**Disclaimer:**

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Neither the above-named supplier nor any of its subsidiaries assumes any liability whatsoever in connection with the information contained herein. NO WARRANTIES ARE MADE, WHETHER EXPRESS OR IMPLIED, INCLUDING WITH RESPECT TO THE COMPLETENESS, ACCURACY OR SUFFICIENCY OF THE FOREGOING, OR ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR ANY IMPLIED WARRANTIES OTHERWISE ARISING FROM COURSE OF DEALING OR TRADE. The user is responsible for determining whether the product is fit for a particular purpose and suitable for user's method of use or application.

Revision: 01/September 2019

Date of Issue:
04 May 2021

# SAFETY DATA SHEET

## 1. SUBSTANCE AND SOURCE IDENTIFICATION

**Product Identifier**

**SRM Number:** 1979
**SRM Name:** Powder Diffraction Line Profile Standard for Crystallite Size Analysis
(Nano-Crystalline Zinc Oxide Powder)
**SRM Part:** Zinc Oxide Powder 15 nm Crystallites
Zinc Oxide Powder 60 nm Crystallites
**Other Means of Identification:** Not applicable.

**Recommended Use of This Material and Restrictions of Use**

This Standard Reference Material (SRM) is intended for use in the analysis of crystallite size through the degree of profile broadening in a powder diffraction experiment. A unit of SRM 1979 consists of two samples of zinc oxide powder, the first with a median crystallite size of approximately 15 nm and a second with a median of approximately 60 nm. Each sample contains approximately 3 g of powder bottled in an argon atmosphere.

**Company Information**

National Institute of Standards and Technology
Standard Reference Materials Program
100 Bureau Drive, Stop 2300
Gaithersburg, Maryland 20899-2300

Telephone: 301-975-2200
E-mail: SRMMSDS@nist.gov
Website: https://www.nist.gov/srm

Emergency Telephone ChemTrec:
1-800-424-9300 (North America)
+1-703-527-3887 (International)

## 2. HAZARDS IDENTIFICATION

**Classification**

| | |
|---|---|
| **Physical Hazard:** | Not classified. |
| **Health Hazard:** | Not classified. |

**Label Elements**

**Symbol:** No symbol/No pictogram.

**Signal Word:** No signal word.

**Hazard Statement(s):** Not applicable.

**Precautionary Statement(s):** Not applicable.

**Hazards Not Otherwise Classified:** Not applicable.

**Ingredients(s) with Unknown Acute Toxicity:** Not applicable.

## 3. COMPOSITION AND INFORMATION ON HAZARDOUS INGREDIENTS

**Substance:** Zinc oxide

**Other Designations:** Zinc white; Chinese white; flowers of zinc; zinc monoxide; zinc gelatin; white zinc; permanent white; philosopher's wool; zincoid; snow white; ZnO

Components are listed in compliance with OSHA 29 CFR 1910.1200; for the actual values see the NIST Certificate of Analysis.

| Hazardous Component(s) | CAS Number | EC Number (EINECS) | Nominal Mass Concentration (%) |
|---|---|---|---|
| Zinc oxide | 1314-13-2 | 215-222-5 | 100 |

## 4. FIRST AID MEASURES

**Description of First Aid Measures:**

**Inhalation:** If adverse effects occur, remove to uncontaminated area. If not breathing, give artificial respiration or oxygen by qualified personnel. Seek immediate medical attention.

**Skin Contact:** Wash skin with soap and water for at least 15

minutes. Thoroughly clean and dry contaminated clothing and shoes before reuse.

**Eye Contact:** Flush eyes with water for at least 15 minutes. If necessary, seek medical attention.

**Ingestion:** If a large amount is swallowed, get medical attention.

**Most Important Symptoms/Effects, Acute and Delayed:** May cause irritation.

**Indication of any immediate medical attention and special treatment needed, if necessary:** If any of the above symptoms are present, seek medical attention if needed.

## 5. FIRE FIGHTING MEASURES

**Fire and Explosion Hazards:** Negligible fire hazard. See Section 9, "Physical and Chemical Properties" for flammability properties.

**Extinguishing Media:**
Suitable: Regular dry chemical, carbon dioxide, water, regular foam.
Unsuitable: None listed.

**Specific Hazards Arising from the Chemical:** None listed.

**Special Protective Equipment and Precautions for Fire-Fighters:** Avoid inhalation of material or combustion byproducts. Wear full protective clothing and NIOSH approved self-contained breathing apparatus (SCBA).

**NFPA Ratings** (0 = Minimal; 1 = Slight; 2 = Moderate; 3 = Serious; 4 = Severe)

Health = 0 Fire = 0 Reactivity = 0

## 6. ACCIDENTAL RELEASE MEASURES

**Personal Precautions, Protective Equipment and Emergency Procedures:** Use suitable protective equipment; see Section 8, "Exposure Controls and Personal Protection".

**Methods and Materials for Containment and Clean up:** Collect spilled material in appropriate container for disposal. Avoid generating dust. Clean up residue with a high-efficiency particulate filter vacuum.

## 7. HANDLING AND STORAGE

**Safe Handling Precautions:** Minimize dust generation. See Section 8, "Exposure Controls and Personal Protection".

**Storage:** It is recommended that the unused portion of the powder be stored in its original bottle, tightly capped and in a dry environment. Store and handling in accordance with all current regulations and standards. Keep separated from incompatible substances (See Section 10, "Stability and Reactivity").

## 8. EXPOSURE CONTROLS AND PERSONAL PROTECTION

**Exposure Limits:**

| | |
|---|---|
| ACGIH (TLV): | 2 mg/m$^3$ (TWA, respirable particulates)<br>10 mg/m$^3$ (STEL, respirable particulates) |
| NIOSH (REL): | 5 mg/m$^3$ (TWA, dust and fume)<br>10 mg/m$^3$ (STEL, fume)<br>15 mg/m$^3$ (Ceiling, dust)<br>500 mg/m$^3$ (IDLH) |

OSHA (PEL): 5 mg/$m^3$ (TWA, fume)
15 mg/$m^3$ (TWA, total dust)
5 mg/$m^3$ (TWA, respirable fraction)

**Engineering Controls:** Provide local exhaust or process enclosure ventilation system. Ensure compliance with applicable exposure limits.

**Personal Protection:** In accordance with OSHA 29 CFR 1910.132, subpart I, wear appropriate Personal Protective Equipment (PPE) to minimize exposure to this material.

**Respiratory Protection:** If workplace conditions warrant a respirator, a respiratory protection program that meets OSHA 29CFR 1910.134 must be followed. Refer to NIOSH 42 CFR 84 for applicable certified respirators.

**Eye/Face Protection:** Wear splash resistant safety goggles with a face shield. An eye wash station should be readily available near areas of use.

**Skin and Body Protection:** Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. Chemical-resistant gloves should be worn at all times when handling chemicals.

## 9. PHYSICAL AND CHEMICAL PROPERTIES

**Descriptive Properties:**

| | |
|---|---|
| **Appearance (physical state, color, etc.):** | white or gray, powder |
| **Molecular Formula:** | $ZnO$ |
| **Molar Mass (g/mol):** | 81.37 |
| **Odor:** | odorless |
| **Odor threshold:** | not available |
| **pH (solution):** | 6.95 to 7.37 |
| **Evaporation rate:** | not applicable |
| **Melting point/freezing point (ºC):** | 1975 (3587 ºF) |
| **Relative Density (g/mL):** | 5.6 |
| **Vapor Pressure (mmHg):** | 0.0 at 21 °C |
| **Vapor Density (air = 1):** | >1 |
| **Viscosity (cP):** | not applicable |
| **Solubility(ies):** | water soluble (1.6 ppm at 29 °C); soluble in dilute acetic acid, mineral acids, ammonia, ammonium chloride solutions, ammonium salt solutions, fixed alkali hydroxide solutions, strong alkali |
| **Partition coefficient (n-octanol/water):** | not available |
| **Particle Size:** | 15 nm or 60 nm (as indicated) |

**Thermal Stability Properties:**

| | |
|---|---|
| **Autoignition Temperature (ºC):** | not applicable |
| **Thermal Decomposition (ºC):** | not available |
| **Initial boiling point and boiling range (ºC):** | not applicable |
| **Explosive Limits, LEL (Volume %):** | not applicable |
| **Explosive Limits, UEL (Volume %):** | not applicable |
| **Flash Point (ºC):** | not applicable |
| **Flammability (solid, gas):** | not available |

## 10. STABILITY AND REACTIVITY

**Reactivity:** Stable at normal temperatures and pressure.

**Stability:** X Stable ______ Unstable

**Possible Hazardous Reactions:** None listed.

**Conditions to Avoid:** Avoid generating dust.

**Incompatible Materials:** Halo carbons, combustible materials, metals, acids, oxidizing materials.

**Fire/Explosion Information:** See Section 5, "Fire Fighting Measures".

**Hazardous Decomposition:** Thermal decomposition will produce zinc, oxides of zinc.

**Hazardous Polymerization:** ______ Will Occur __X__ Will Not Occur

## 11. TOXICOLOGICAL INFORMATION

**Route of Exposure:** __X__ Inhalation ______ Skin __X__ Ingestion

**Symptoms Related to the Physical, Chemical and Toxicological Characteristics:** Exposure may cause irritation.

**Potential Health Effects (Acute, Chronic and Delayed):**

**Inhalation:** Acute: irritation; inhaled fumes may cause metal fume fever, difficulty breathing; chronic: nausea and liver damage.

**Skin Contact:** Acute: low potential for skin irritation, although it can alter skin pigmentation; chronic: skin disorders.

**Eye Contact:** Acute: mechanical irritation, redness, and pain; chronic: no information available.

**Ingestion:** Acute: nausea, diarrhea, constipation; chronic: no information available.

**Numerical Measures of Toxicity:**

**Acute Toxicity:** Not classified.
Rat, Oral LD50: >5000 mg/kg
Mouse, Inhalation LC50: 2500 mg/m$^3$

**Skin Corrosion/Irritation:** Not classified.
Rabbit, Skin (mild): 500 mg (24 h)

**Serious Eye Damage/Irritation:** Not classified.
Rabbit, Eyes (mild): 500 mg (24 h)

**Respiratory Sensitization:** Not classified; no data available.

**Skin Sensitization:** Not classified; no data available.

**Germ Cell Mutagenicity:** Not classified; no data available.

**Carcinogenicity:** Not classified.

**Listed as a Carcinogen/Potential Carcinogen** ______ Yes __X__ No
Zinc oxide is not listed by IARC, NTP or OSHA as a carcinogen.

**Reproductive Toxicity:** Not classified.
Rat, Oral TDLo: 6846 mg/kg (pregnant 1 d to 22 d)

**Specific Target Organ Toxicity, Single Exposure:** Not classified; no data available.

**Specific Target Organ Toxicity, Repeated Exposure:** Not classified; no data available.

**Aspiration Hazard:** Not classified; no data available.

## 12. ECOLOGICAL INFORMATION

**Ecotoxicity Data:** No data available.
**Persistence and Degradability:** No data available.
**Bioaccumulative Potential:** No data available.
**Mobility in Soil:** No data available.
**Other Adverse effects:** No data available.

## 13. DISPOSAL CONSIDERATIONS

**Waste Disposal:** Dispose of waste in accordance with all applicable federal, state, and local regulations.

## 14. TRANSPORTATION INFORMATION

**U.S. DOT and IATA:** Not regulated by DOT or IATA.

## 15. REGULATORY INFORMATION

**U.S. Regulations:**

CERCLA Sections 102a/103 (40 CFR 302.4): Not regulated.
SARA Title III Section 302 (40 CFR 355.30): Not regulated.
SARA Title III Section 304 (40 CFR 355.40): Not regulated.
SARA Title III Section 313 (40 CFR 372.65): 1.0 % de minimis concentration (related to Zinc compounds).
OSHA Process Safety (29 CFR 1910.119): Not regulated.
SARA Title III Sections 311/312 Hazardous Categories (40 CFR 370.21):

| | |
|---|---|
| ACUTE HEALTH: | No. |
| CHRONIC HEALTH: | No. |
| FIRE: | No. |
| REACTIVE: | No. |
| PRESSURE: | No. |

**State Regulations:**
California Proposition 65: Not listed.

**U.S. TSCA Inventory:** Listed.

**TSCA 12(b), Export Notification:** Not listed.

**Canadian Regulations:**
WHMIS Information: Not provided for this material.

## 16. OTHER INFORMATION

**Issue Date:** 04 May 2021

**Sources:** ChemADVISOR, Inc., SDS *Zinc Oxide*, 09 December 2015.

CDC_NIOSH_Pocket_Guide_to_Chemical_Hazards Zinc oxide; available at https://www.cdc.gov/niosh/npg/npgd0675.html (accessed May 2021).

**Key of Acronyms:**

| | | | |
|---|---|---|---|
| ACGIH | American Conference of Governmental Industrial Hygienists | NIOSH | National Institute for Occupational Safety and Health |
| ALI | Annual Limit on Intake | NIST | National Institute of Standards and Technology |
| CAS | Chemical Abstracts Service | NRC | Nuclear Regulatory Commission |
| CEN | European Committee for Standardization | NTP | National Toxicology Program |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act | OSHA | Occupational Safety and Health Administration |
| CFR | Code of Federal Regulations | PEL | Permissible Exposure Limit |
| CPSU | Coal Mine Dust Personal Sample Unit | RCRA | Resource Conservation and Recovery Act |
| DOT | Department of Transportation | REL | Recommended Exposure Limit |
| EC50 | Effective Concentration, 50 % | RM | Reference Material |
| EINECS | European Inventory of Existing Commercial Chemical Substances | RQ | Reportable Quantity |
| EPCRA | Emergency Planning and Community Right-to-Know Act | RTECS | Registry of Toxic Effects of Chemical Substances |
| IARC | International Agency for Research on Cancer | SARA | Superfund Amendments and Reauthorization Act |
| IATA | International Air Transport Association | SCBA | Self-Contained Breathing Apparatus |
| IDLH | Immediately Dangerous to Life and Health | SRM | Standard Reference Material |
| ISO | International Organization for Standardization | STEL | Short Term Exposure Limit |
| LC50 | Lethal Concentration, 50 % | TDLo | Toxic Dose Low |
| LD50 | Lethal Dose, 50 % | TLV | Threshold Limit Value |
| LEL | Lower Explosive Limit | TPQ | Threshold Planning Quantity |
| MSDS | Material Safety Data Sheet | TSCA | Toxic Substances Control Act |
| NFPA | National Fire Protection Association | TWA | Time Weighted Average |
| MSHA | Mine Safety and Health Administration | UEL | Upper Explosive Limit |
| | | WHMIS | Workplace Hazardous Materials Information System |

**Disclaimer:** The NIST SDS information is specific to the NIST product and is believed to be correct, based upon our current knowledge. The SDS may not necessarily be all inclusive and should be used only as a guide. NIST does not guarantee the accuracy or completeness of this information. The only official source for specific values and uncertainties is the certificate or report.

Users of this SRM should ensure that the SDS in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-2200; e-mail srmmsds@nist.gov; or via the Internet at https://www.nist.gov/srm.

# ZINC SULPHATE SOLUTION
# SAFETY DATA SHEET

## SECTION 1. IDENTIFICATION

**Product Identity:** Zinc Sulphate Solution.

**Trade Names and Synonyms:** Zinc Sulfate Solution, Zinc Electrolyte, Neutral Zinc Sulfate.

| **Manufacturer:** | **Supplier:** | **Preparer:** |
|---|---|---|
| Teck Metals Ltd.<br>Trail Operations<br>Trail, British Columbia<br>V1R 4L8<br>Emergency Telephone: 250-364-4214 | Teck Metals Ltd.<br>Trail Operations<br>Trail, British Columbia<br>V1R 4L8 | Teck Metals Ltd.<br>Suite 3300 – 550 Burrard Street<br>Vancouver, British Columbia<br>V6C 0B3 |

**Date of Last Review:** August 14, 2018.

**Date of Last Edit:** August 14, 2018.

**Product Use:** Used as a micronutrient in fertilizer and feed supplements, may also be used as a floatation additive in mining.

## SECTION 2. HAZARDS IDENTIFICATION

**CLASSIFICATION:**

| Health | | Physical | Environmental |
|---|---|---|---|
| Acute Toxicity (Oral, Inhalation) | – Does not meet criteria | Does not meet criteria for any Physical Hazard | **Aquatic Toxicity – Short Term – Category 1** |
| Skin Corrosion/Irritation | – Does not meet criteria | | |
| **Eye Damage/Eye Irritation** | **– Category 2A** | | |
| Respiratory or Skin Sensitization | – Does not meet criteria | | |
| Mutagenicity | – Does not meet criteria | | |
| Carcinogenicity | – Does not meet criteria | | |
| Reproductive Toxicity | – Does not meet criteria | | |
| Specific Target Organ Toxicity | | | |
| Acute Exposure | – Does not meet criteria | | |
| Chronic Exposure | – Does not meet criteria | | |

**LABEL:**

| | |
|---|---|
| **Symbols:**  | **Signal Word:**<br>**WARNING** |
| **Hazard Statements**<br>**WARNING!**<br>Causes serious eye irritation.<br>Very toxic to aquatic life. | **Precautionary Statements:**<br>Wear eye protection/face protection.<br>Wash contaminated skin thoroughly after handling.<br>Avoid release to the environment. Collect spillage.<br>IF IN EYES: Rinse continuously with water for several minutes. If eye irritation persists: get medical advice/ attention. |

**Emergency Overview:** A clear or slightly opaque solution that does not burn or readily decompose. It consists principally of dissolved zinc sulphate. The solution is relatively non-toxic to humans and poses little immediate hazard to personnel in an emergency situation but contains a high concentration of dissolved zinc and can pose a threat to watercourses.

**Potential Health Effects:** Direct eye contact with the solution is likely to cause eye irritation. Dried residues may cause eye, nose & throat irritation and, when heated strongly in air, will generate zinc oxide fume. Inhalation of freshly formed zinc oxide fume can result in metal fume fever, a temporary flu-like condition (see Toxicological Information, Section 11).

**Potential Environmental Effects:** As this product is a solution, the contained zinc, in elevated concentrations, is directly bioavailable and is potentially toxic to aquatic and soil organisms and plants (see Ecological Information, Section 12).

## SECTION 3. COMPOSITION / INFORMATION ON INGREDIENTS

| COMPONENTS | CAS Registry No. | CONCENTRATION (% wt/wt) |
|---|---|---|
| Zinc Sulphate | 7733-02-0 | 29-34% |
| Magnesium Sulphate | 7487-88-9 | 0.4-1.5% |
| Manganese Sulphate | 7785-87-7 | 0.3-0.5% |

Note: See Section 8 for Occupational Exposure Guidelines.

## SECTION 4. FIRST AID MEASURES

**Eye Contact:** *Symptoms:* Eye irritation, redness. If irritation occurs, cautiously rinse eyes with lukewarm, gently flowing water for 5 minutes, while holding the eyelids open. If eye irritation persists: Get medical advice/attention.

**Skin Contact:** *Symptoms:* Mild irritation. Rinse/wash with lukewarm, gently flowing water (and mild soap) for 5 minutes or until product is removed. If skin irritation occurs or you feel unwell: Get medical advice/attention.

**Inhalation:** *Symptoms:* Respiratory irritation. Get medical advice/attention if you feel unwell or are concerned.

**Ingestion:** *Symptoms:* Stomach upset. If swallowed, no specific intervention is indicated as this material is not likely to be hazardous by ingestion. If you feel unwell or are concerned: Get medical attention.

## SECTION 5. FIRE FIGHTING MEASURES

**Fire and Explosion Hazards:** This product is not considered a fire or explosion hazard.

**Extinguishing Media:** Use any means of extinction appropriate for surrounding fire conditions such as water spray, carbon dioxide, dry chemical, or foam.

**Fire Fighting:** As with any fire, fire fighters should be fully trained and wear full protective clothing including an approved, self-contained breathing apparatus which supplies a positive air pressure within a full face piece mask.

## SECTION 6. ACCIDENTAL RELEASE MEASURES

**Procedures for Cleanup:** Stop release if possible to do so safely. Contain spill, isolate hazard area, and deny entry. Pump back into system if possible. Otherwise absorb with any suitable absorbent such as vermiculite or clay. Place contaminated material in suitable, labeled containers for final disposal. Dispose of waste material consistent with the requirements of waste disposal authorities.

**Personal Precautions:** Impervious chemical-resistant gloves, rubber boots and coveralls or other protective clothing are recommended for persons responding to an accidental release (see also Section 8). Close-fitting safety goggles may be necessary in some circumstances to prevent eye contact with the solution.

**Environmental Precautions:** Spilled product can pose immediate risks to aquatic and terrestrial environments. Released product should be prevented from reaching soil or entering watercourses in the vicinity of product handling areas.

## SECTION 7. HANDLING AND STORAGE

**Precautions for Safe Handling:** Avoid generating mist or aerosol and its release into the work environment. Do not perform any welding, cutting or other hot work on empty vessels, containers, or piping until all liquid and/or dried residues have been cleared. Always practice good personal hygiene. Refrain from eating, drinking or smoking in work areas. Thoroughly wash hands after handling and before eating, drinking or smoking in appropriate designated areas only.

**Conditions for Safe Storage:** Store in a dry, cool, well-ventilated area away from incompatible substances. Inspect storage area periodically for damage or leaks.

## SECTION 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

**Occupational Exposure Guidelines (OEGs):** *(Time-Weighted Average (TWA) concentration over 8 hr unless otherwise indicated)*

| Component | ACGIH TLV | OSHA PEL | NIOSH REL |
|---|---|---|---|
| Zinc Sulphate | None Established | None Established | None Established |
| Magnesium Sulphate | None Established | None Established | None Established |
| Manganese Sulphate | 0.02 mg Mn/m$^3$ Respirable<br>0.1 mg Mn/m$^3$ Inhalable | 5 mg Mn/m$^3$ Ceiling | 1 mg Mn/m$^3$ TWA |

NOTE: OEGs for individual jurisdictions may differ from those given above. Check with local authorities for the applicable OEGs in your jurisdiction.
ACGIH - American Conference of Governmental Industrial Hygienists; OSHA - Occupational Safety and Health Administration; NIOSH - National Institute for Occupational Safety and Health. TLV – Threshold Limit Value, PEL – Permissible Exposure Limit, REL – Recommended Exposure Limit.

*NOTE: The selection of the necessary level of engineering controls and personal protective equipment will vary depending upon the conditions of use and the potential for exposure. The following are therefore only general guidelines that may not fit all circumstances. Control measures to consider include:*

**Ventilation:** Use adequate local or general ventilation to maintain the concentration of aerosol mists well below recommended occupational exposure limits.

**Protective Clothing:** Impervious, chemical-resistant gloves are recommended when handling bulk solution. Eye protection should be worn where mist is generated and where any possibility exists that eye contact may occur.

**Respirators:** Where liquid aerosol mists are generated and cannot be controlled to within acceptable levels, use appropriate NIOSH-approved respiratory protection equipment (42 CFR 84 Class N, R or P-95 particulate filter as a minimum).

**General Hygiene Considerations:** Always practice good personal hygiene. Refrain from eating, drinking, or smoking in work areas. Thoroughly wash hands after handling and before eating, drinking, or smoking in appropriate designated areas only.

## SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

| | | | |
|---|---|---|---|
| **Appearance:**<br>Clear to slightly opaque liquid | **Odour:**<br>None | **Odour Threshold:**<br>Not Applicable | **pH:**<br>Approx. 4.5 – 5.0 |
| **Vapour Pressure:**<br>Negligible @ 20°C | **Vapour Density:**<br>Not Applicable | **Freezing Point/Range:**<br>Not Available | **Boiling Point/Range:**<br>Not Available |
| **Relative Density** (Water = 1)**:**<br>1.25- 1.35 | **Evaporation Rate:**<br>Not Applicable | **Coefficient of Water/Oil Distribution:** Not Available | **Solubility:**<br>Aqueous Solution |
| **Flashpoint:**<br>Non- Flammable Liquid | **Flammable Limits (LEL/UEL):**<br>Not Applicable | **Auto-ignition Temperature:**<br>None | **Decomposition Temperature:**<br>None |
| **Viscosity:**<br>Not Available | | | |

## SECTION 10. STABILITY AND REACTIVITY

**Stability & Reactivity:** This material is stable and not considered reactive under normal temperatures and pressures. Hazardous polymerization or runaway reactions will not occur.

**Incompatibilities:** None have been identified.

**Hazardous Decomposition Products:** High temperature operations such as oxy-acetylene cutting, electric arc welding or overheating of dried residues will generate zinc oxide fume which, on inhalation in sufficient quantity, can produce metal fume fever. Under such conditions, sulphur dioxide will also be generated and can cause respiratory distress.

## SECTION 11. TOXICOLOGICAL INFORMATION

**General:** In the form in which this product is sold it is relatively non-toxic. The major route of exposure would be through the generation and inhalation of aerosol mist, or the generation of zinc oxide fume through welding or burning around dried residues.

**Acute:**
**Skin/Eye:** Contact with liquid is likely to cause eye irritation and may cause local skin irritation but would not result in permanent tissue damage. Dust or fume from burning or welding on dried residues may also cause local irritation.

**Inhalation:** Acute inhalation of mists may result in some mild irritation of the nose, throat and/or upper respiratory passages. Symptoms may include discomfort, coughing, tingling sensation, sneezing and/or shortness of breath and wheezing. Excessive heating of dried zinc sulphate residues will generate zinc oxide fume. If inhaled, this fume can result in the condition called metal fume fever. The symptoms of metal fume fever will occur within 3 to 10 hours of exposure, and include immediate dryness and irritation of the throat, tightness of the chest, and coughing which may later be followed by flu-like symptoms of fever, malaise, perspiration, frontal headache, muscle cramps, low back pain, occasionally blurred vision, nausea, and vomiting. The symptoms are temporary and generally disappear, without medical intervention, within 24 to 48 hours of onset. There are no recognized complications, after affects, or chronic affects that result from this condition.

**Ingestion:** Zinc sulphate is very astringent, and when ingested in excessive quantities can irritate the stomach, resulting in nausea and spontaneous vomiting.

**Chronic:** Prolonged skin contact with zinc sulphate solution may cause skin dermatitis. Zinc, magnesium and manganese are not listed as carcinogens by the Occupational Safety and Health Administration (OSHA), the National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC), or the American Conference of Governmental Industrial Hygienists (ACGIH).

**Animal Toxicity:**

| **Ingredient:** | **Acute Oral Toxicity:** | **Acute Dermal Toxicity:** | **Acute Inhalation Toxicity:** |
|---|---|---|---|
| Zinc Sulphate | $LD_{50}$ 1,538 mg/kg† | No data | No data |
| Magnesium Sulphate | $LD_{50}$ >5,000 mg/kg† | No data | No data |
| Manganese Sulphate | $LD_{50}$ 2,150 mg/kg† | No data | $LC_{50}$ >4.45 mg/L‡ |

† $LD_{50}$, Rat, Oral,

‡ $LC_{50}$, Rat, Inhalation, 4 hour

## SECTION 12. ECOLOGICAL INFORMATION

In elevated concentrations, zinc sulphate in solution is potentially toxic to aquatic and terrestrial organisms. However, processes in the environment may alter its bioavailability in diluted form. In aquatic systems, zinc has the potential to bioaccumulate in both plants and animals. In terrestrial systems, the mobility of zinc in soil depends primarily on soil conditions, such as cation exchange capacity, pH, redox potential, and chemical species present in the soil. Zinc also bioaccumulates in terrestrial plants, vertebrates, and mammals, with plant uptake from soil dependent on plant species, soil pH, and soil composition.

## SECTION 13. DISPOSAL CONSIDERATIONS

Do not wash down drain. Dike area around spill and pump uncontaminated solution back to process if possible, then absorb any remaining liquid in a solid absorbent such as vermiculite or clay. Place contaminated material in suitable, labeled containers for final disposal. Dispose of waste material consistent with the requirements of waste disposal authorities.

## SECTION 14. TRANSPORT INFORMATION

| | |
|---|---|
| PROPER SHIPPING NAME U.S. DOT | Environmentally Hazardous Substance, Liquid, n.o.s. (contains Zinc Sulfate) |
| TRANSPORT CANADA CLASSIFICATION | Not regulated |
| U.S. DOT CLASSIFICATION | Class 9, Packing Group III (RQ) |
| PRODUCT IDENTIFICATION NUMBER | UN3082 |
| MARINE POLLUTANT | No |
| IMO CLASSIFICATION | Not regulated |

## SECTION 15. REGULATORY INFORMATION

**U.S.**

| | |
|---|---|
| INGREDIENTS LISTED ON TSCA INVENTORY | Yes |
| HAZARDOUS UNDER HAZARD COMMUNICATION STANDARD | Yes |
| CERCLA SECTION 103 HAZARDOUS SUBSTANCES | Zinc Sulfate ...... RQ: 1,000lbs.<br>Manganese Compounds... RQ: None Assigned |
| EPCRA SECTION 302 EXTREMELY HAZARDOUS SUBSTANCE | No Ingredients Qualify |
| EPCRA SECTION 311/312 HAZARD CATEGORIES | Eye/Skin Irritant |

EPCRA SECTION 313 TOXIC RELEASE INVENTORY:........................ Zinc Compounds (Zinc Sulfate)
CAS No. 7733-02-0
Percent by Weight............ 29-34%
Manganese Compounds (Manganese Sulfate)
CAS No. 7785-87-7
Percent by Weight............ 0.3-0.5%

**CANADA**
INGREDIENTS LISTED ON DOMESTIC SUBSTANCES LIST ............. Yes.

## SECTION 16. OTHER INFORMATION

| | | | |
|---|---|---|---|
| **Date of Original Issue:** | May 9, 2001 | **Version:** | 01 *(First edition)* |
| **Date of Latest Revision:** | August 14, 2018 | **Version:** | 11 |

The information in this Safety Data Sheet is based on the following references:

- American Conference of Governmental Industrial Hygienists, 2004, Documentation of the Threshold Limit Values and Biological Exposure Indices, Seventh Edition plus updates.
- American Conference of Governmental Industrial Hygienists, 2018, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.
- American Conference of Governmental Industrial Hygienists, 2018, Guide to Occupational Exposure Values.
- Bretherick's Handbook of Reactive Chemical Hazards, 20th Anniversary Edition. (P. G. Urben Ed.) 1995.
- Canadian Centre for Occupational Health and Safety (CCOHS) CHEMpendium Chemical Information Data Base, 2015.
- Health Canada, SOR/2015-17, Hazardous Products Regulations, 11 February 2015.
- International Agency for Research on Cancer (IARC), Monograms on the Evaluation of the Carcinogenic Risk of Chemicals to Man, 1972 – present, (multi-volume work), World Health Organization, Geneva.
- Merck & Co., Inc., 2001, The Merck Index, An Encyclopedia of Chemicals, Drugs, and Biologicals, Thirteenth Edition.
- Patty's Toxicology, Fifth Edition, 2001: E. Bingham, B. Cohrssen & C.H. Powell, Ed.
- U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, NIOSH Pocket Guide to Chemical Hazards. CD-ROM Edition, September 2005.
- U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, Registry of Toxic Effects of Chemical Substances (RTECS) online version last accessed 2018-07-31.
- U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, National Toxicology Program (NTP), 14th Report on Carcinogens, November 2016.
- U.S. Occupational Safety and Health Administration, 1989, Code of Federal Regulations, Title 29, Part 1910.1000 and 1910.1200.

**Acronyms not spelled out elsewhere in the SDS:**
CAS: Chemical Abstracts Service
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
DOT: Department of Transport
EPCRA: Emergency Planning and Community Right-to-Know Act
IMO: International Maritime Organization
$LD_{50}$ $LC_{50}$: Lethal Dose 50%, Lethal Concentration 50%
TSCA: Toxic Substances Control Act
Wt: Weight

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