URBAN MINING OF RARE EARTH ELEMENTS FROM RARE EARTH MAGNETS - HYDROMETALLURGICAL PROCESSING

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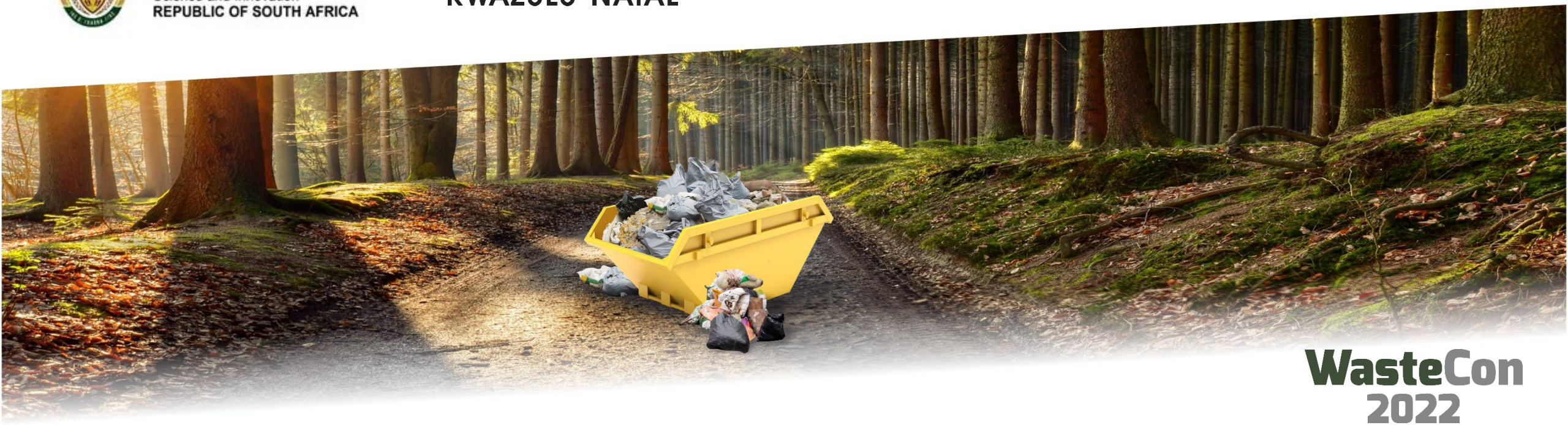


WasteCon 2022

Sustainable development goals

- The 2030 Agenda
- Environment action programme to 2030
- Climate-neutral economy by 2050

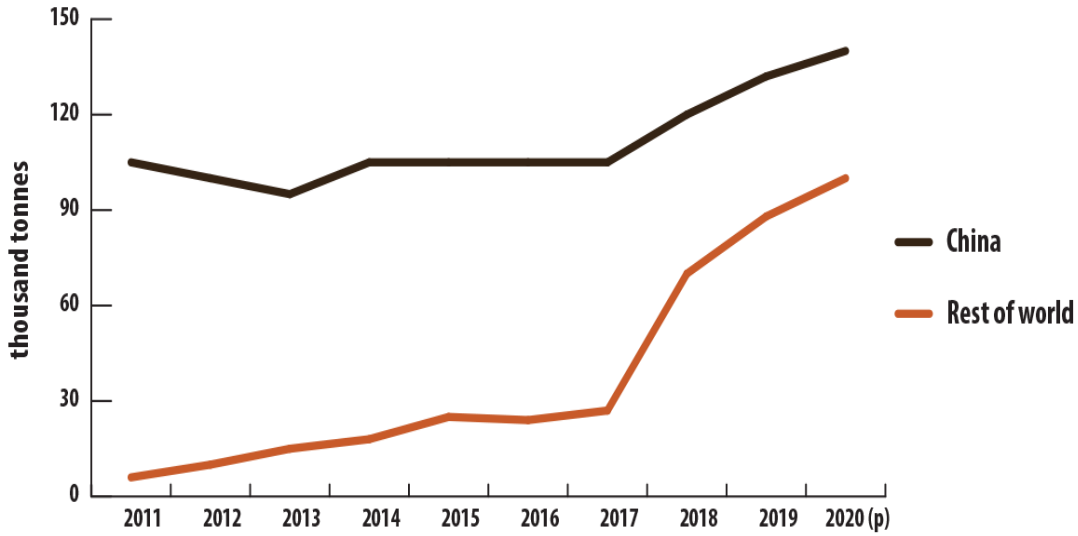
Only 12% of eWaste generated in South Africa is processed [1]

Rare Earth Elements

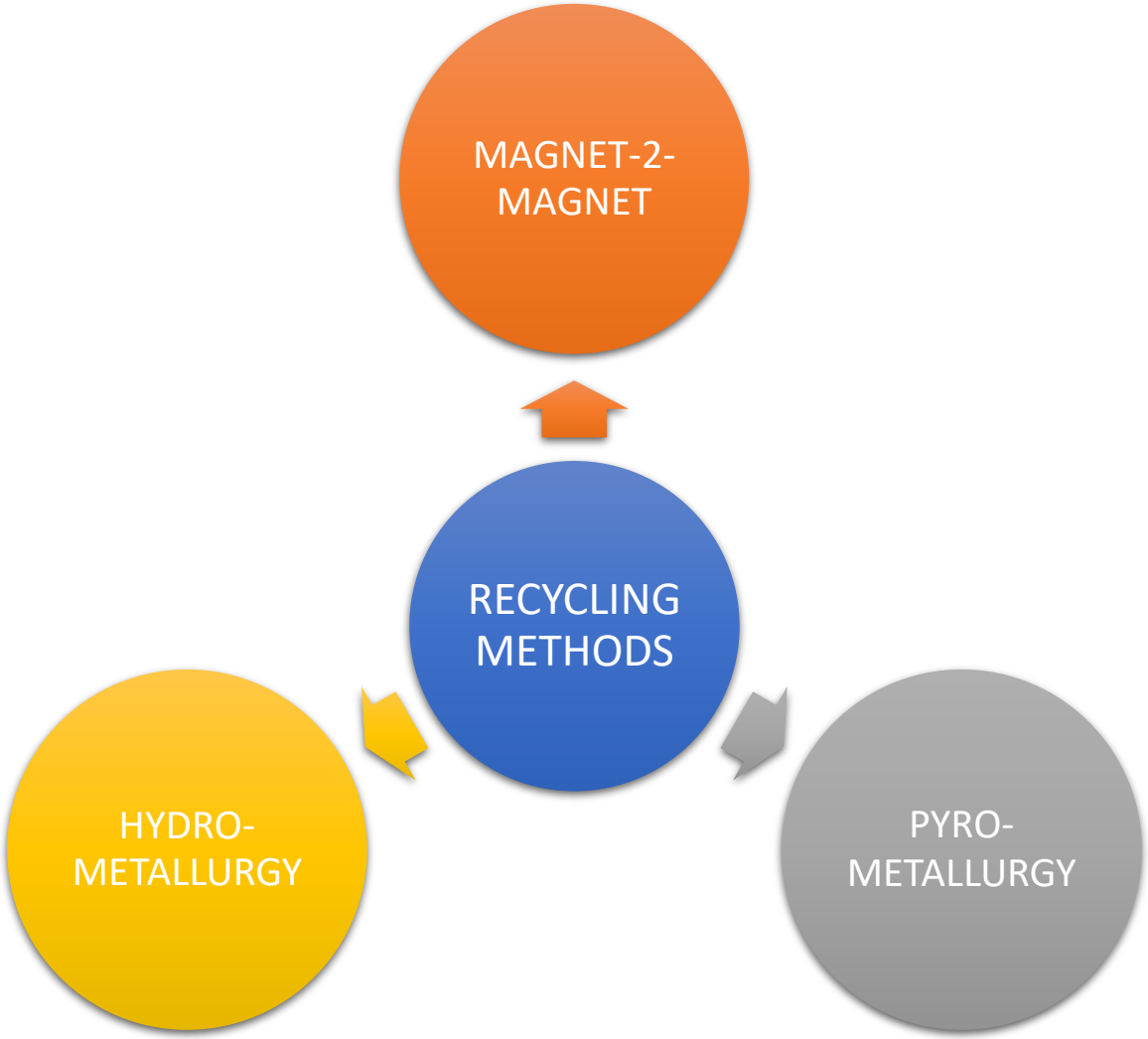
World production of REEs, by country in 2020 [2]

Country	Percentage of total production/%
China	57.5
United States	15.6
Myanmar	12.3
Australia	7.0
Madagascar	3.3
Other	4.2

World production of REEs , 2011-2020 [2]



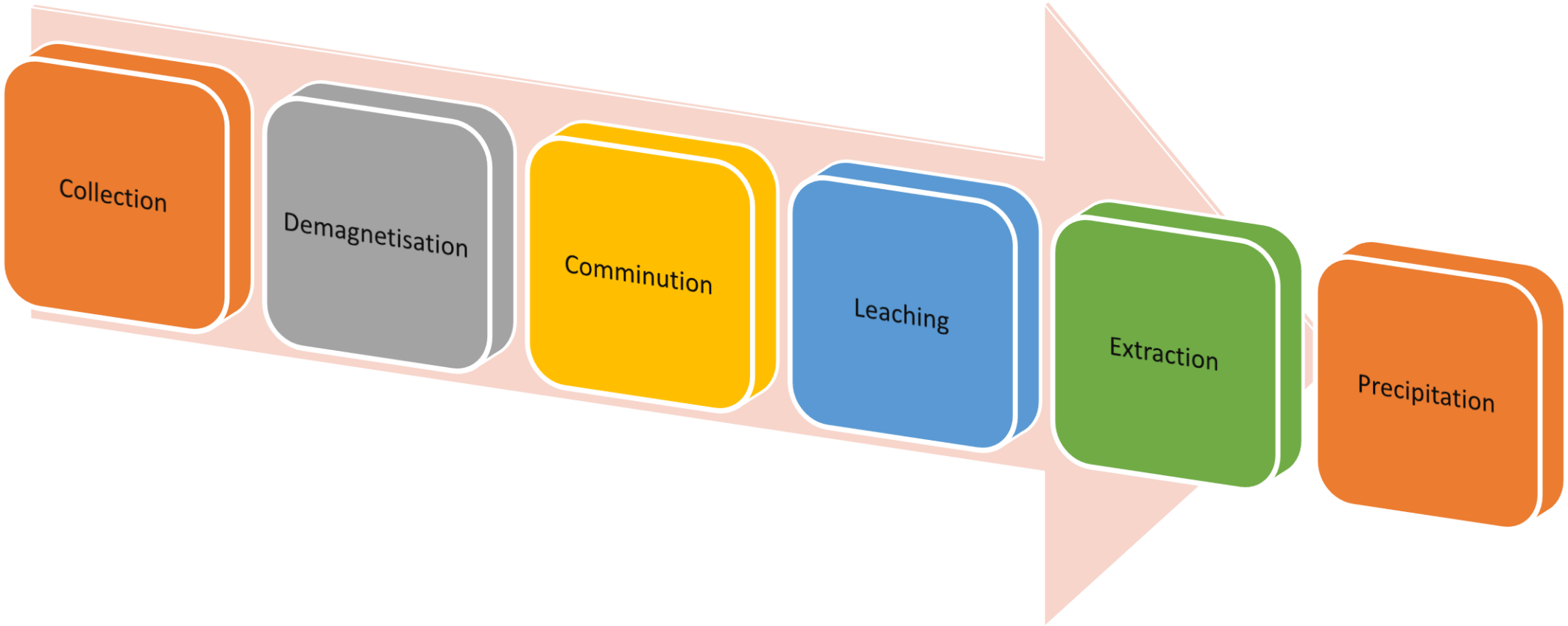
Methods of Waste Permanent Magnets (WPM) recycling



EUROPEAN WPM RECYCLING PLANTS [3]

- STENA Recycling (Sweden) – 6 tonnes of NdFeB powders per annum
- University of Birmingham (UK) – 50 tonnes of NdFeB powders per annum
- Magneti Ljubljana (Slovenia) - 50 tonnes of NdFeB powders per annum
- MIMplus Technologies (Germany) – 10 tonnes of NdFeB powders per annum

Hydrometallurgy



Hydrometallurgy – chemistry of the process

Ranges of concentrations of elements in NdFeB magnets [4,5,6]

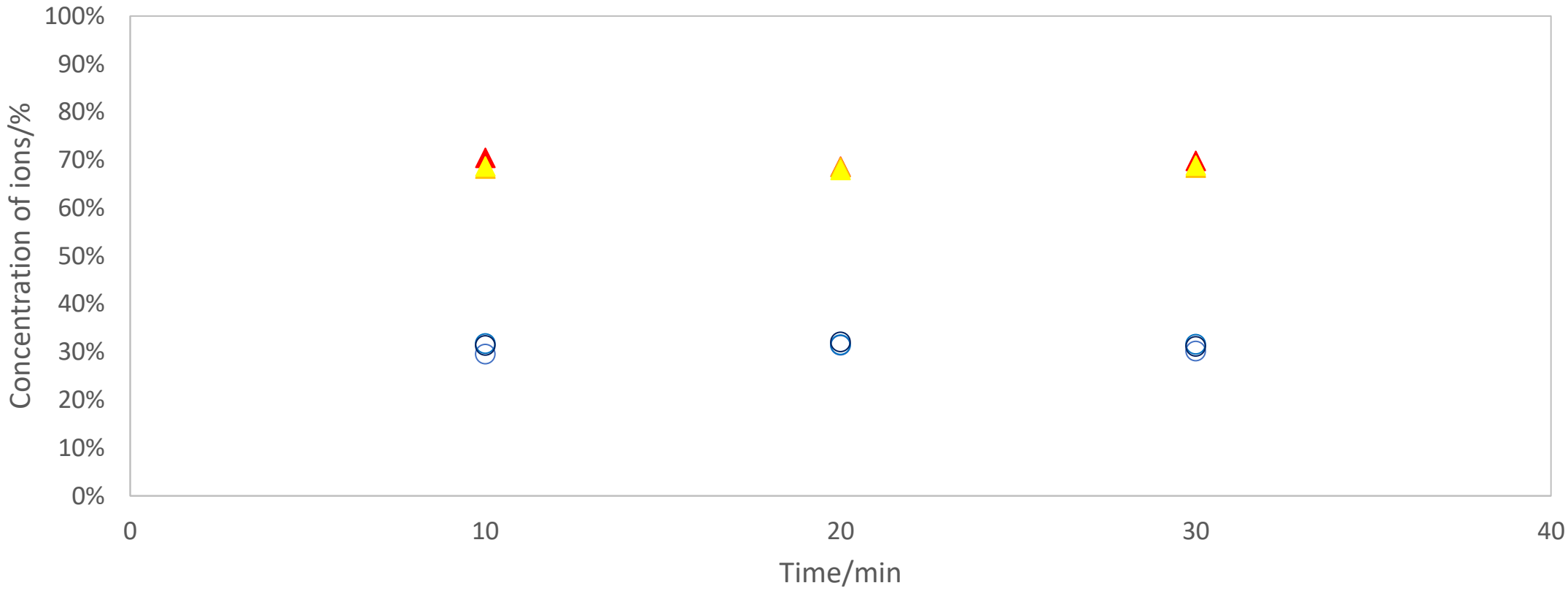
Fe^{3+}	Nd^{3+}	Dy^{3+}	Pr^{3+}	B^{3+}	Sm^{3+}
~59-69%	~22-33%	~0.5-5%	~1-7%	~1-2.5%	~0.6-1.6%

$$\mathrm{RE} + 3H^{+}X^{-}_{(aq)} \rightarrow RE^{3+}_{(aq)} + 3\mathrm{X}^{-}_{(aq)} + 1.5H_{2\,(g)}$$

Hydrometallurgy - leaching

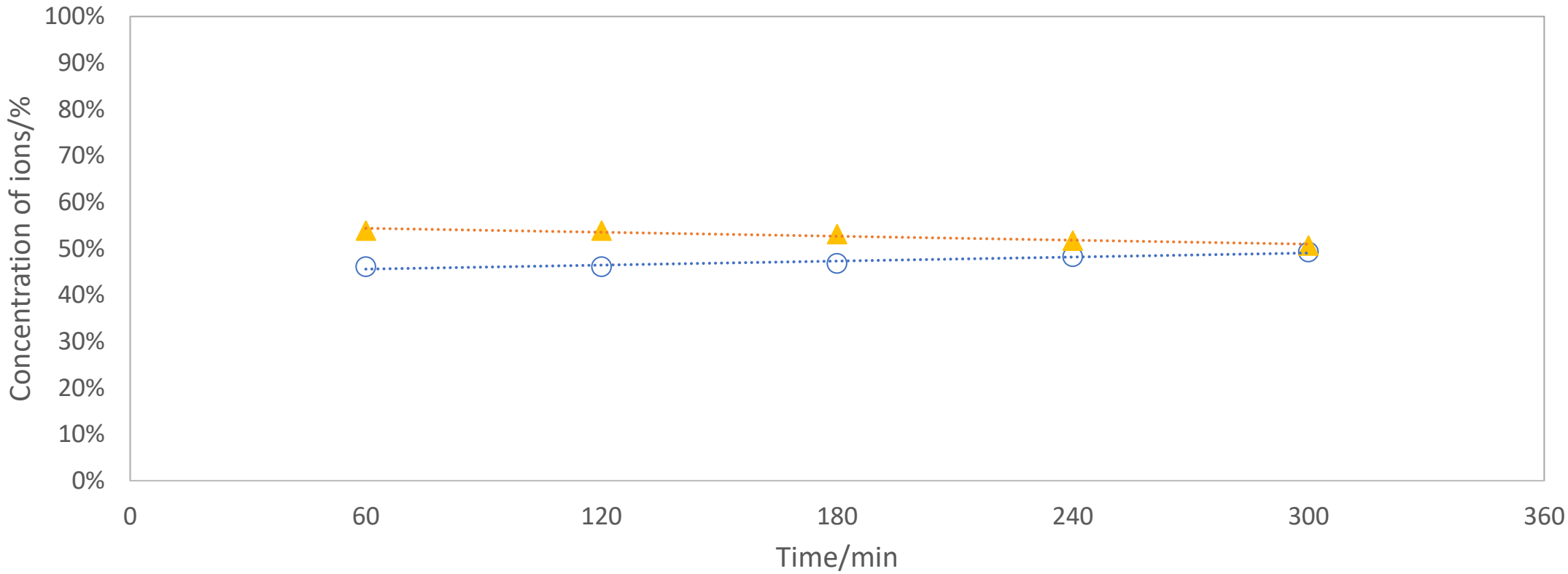
Concentrations of Fe^{3+} (▲ 100-150µm, ▲ 425-500µm, ▲ ≥600µm) and Nd^{3+} (○ 100-150µm, ○ 425-500µm, ○ ≥600µm) ions in the pregnant leach solution of particle size test. 2.2M HNO_3, T = 298.15 K, t = 30 min.

Hydrometallurgy - leaching



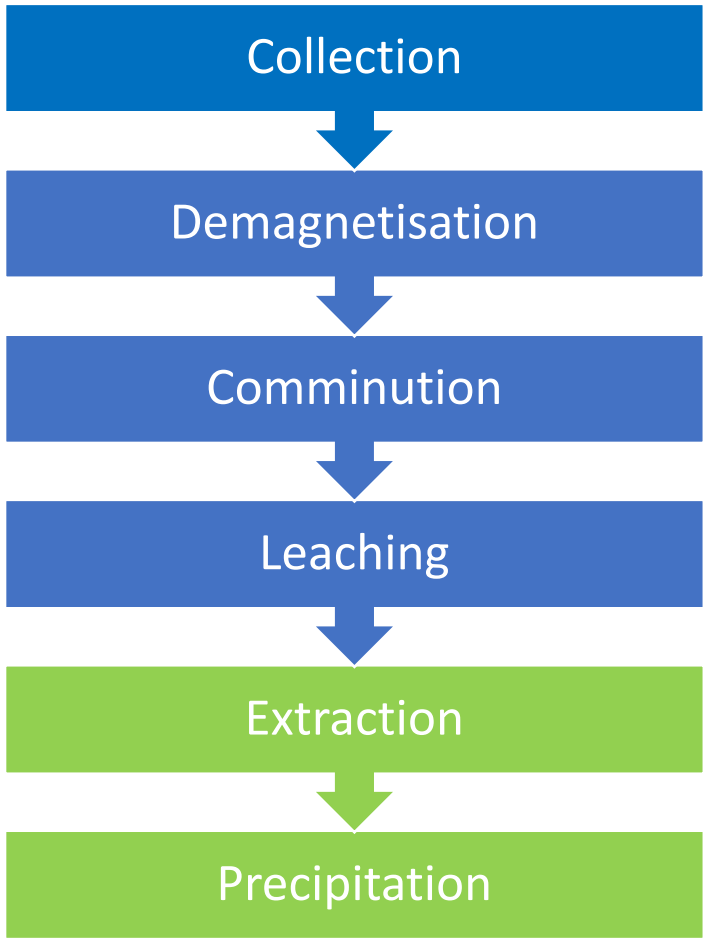
Concentrations of Fe^{3+} (▲ 2.2M HNO_3, ▲ 6.7M HNO_3, ▲ 12.3M HNO_3) and Nd^{3+} (○ 2.2M HNO_3, ○ 6.7M HNO_3, ○ 12.3M HNO_3) ions in the pregnant leach solution of acid concentration test. Particle size = 425-500 µm, T = 298.15 K, t = 30 min.

Hydrometallurgy - leaching



Concentrations of Fe^{3+} (▲) and Nd^{3+} (○) ions in the pregnant leach solution of contact time test.
Particle size = 425-500 µm, 12.3M HNO_3, T = 298.15 K.

Hydrometallurgy – future development



- Creation of new jobs
- Reuse of the materials
- Sustainable development
- Interdisciplinary cooperation

Acknowledgments

Waste RDI

References

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NdFeB permanent magnets

Source	Fe^{3+}	Nd^{3+}	Dy^{3+}	Pr^{3+}	B^{3+}	Sm^{3+}	Reference
NdFeB magnet powder (75-100 µm particle size)	68.45	24.48	2.74	1.24	2.44	0.65	This work
NdFeB magnet powder (100-150 µm particle size)	67.70	23.85	2.47	3.08	2.27	0.63	This work
NdFeB magnet powder (425-500 µm particle size)	67.80	22.58	1.50	4.50	2.00	1.62	This work
NdFeB scrap magnet	59.62	31.27	-	-	1.26	-	(Lee et al., 2013)
NdFeB powder without roasting	58.50	32.36	1.00	4.38	-	-	(Reisdörfer et al., 2019)
NdFeB powder with roasting	66.69	25.19	0.72	2.96	-	-	(Reisdörfer et al., 2019)
PC HDD (before 2005)	59.40	24.44	1.39	1.85	-	-	(Gruber et al., 2020)
PC HDD (2010-2015)	61.33	25.94	2.14	0.81	-	-	(Gruber et al., 2020)
Servomotors	64.86	19.54	4.63	5.92	-	-	(Gruber et al., 2020)
Traction engine	61.15	18.76	4.05	5.72	-	-	(Gruber et al., 2020)
Magnetic separator	62.70	23.80	1.25	6.66	-	-	(Gruber et al., 2020)