Methodologies for Environmental Impact Assessment of

Deep Sea Tailings Disposal (DSTP) projects.

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Abstract.

Mining creates mineral waste that has to be managed. The main challenge is that the volumes of mineral waste (tailings and waste rock) are large and sufficient and safe storage capacity has to be available. Sea disposal, deep or shallow, is a potential alternative to land disposal. Environmental impact assessment for the next generation projects is a challenge for all the actors involved: the mining industry, regulators, scientists, stakeholders etc. Permits for waste management are dependent on what is considered as environmental acceptable. And the mining industry needs predictable terms and a roadmap for waste management. Comparisons of different waste disposal alternatives are necessary on the basis of risk potential with different types of waste. Acceptance criteria communicated with stakeholders to distinguish between "anticipated" risk based on emotions and "real" risks based on scientific documentations are needed. Knowledge contributes to increase the focus on «real» risk. This paper is focusing on environmental impact assessment for DSTP projects.

Introduction

Mining of metals and minerals generate large quantities of tailings and waste rock (Skei, 2013; 2014). To obtain permit for waste management, an Environmental Impact Assessment (EIA) is required in most countries, where alternative management methods are compared and weighed in terms of environmental risk and sustainability.

Traditionally, tailings and waste rock have been placed on land. Tailings in artificial dams or existing lakes downstream the processing plant; and the waste rocks in heaps near the mine site. An alternative which has not been used frequently is backfilling in mine shafts. The success related to land disposal is very much dependent on climatic conditions and seismic activity. In areas of high rainfall, land disposal create a lot of challenges with respect to dam safety and flooding of vacated mine shafts, where backfilling of tailing and/or waste rocks has been practised. This often creates environmental concern due to contaminated mine water which influence the water quality (low pH and high levels of dissolved metals) in rivers, lakes and the surface of the sea (Arnesen et. al, 1997). Climatic changes take place in many areas of the world, causing increase in rainfall and increased frequency of floods. Consequently, this increases risk of dam failure and damage to human health and natural resources (i.e. dam failure at Los Frailes, Spain, 1998). As a result next generation mining projects must look carefully at the potential environmental impacts and risks of waste management. Additionally, the competition of land areas is increasing. Implementation of sea disposal of tailings is an alternative which should be evaluated and weighed with respect to environmental risk of land disposal.

Sea disposal of mine tailings

Disposal of mine tailings to sea (STD) has been practised in some coastal states for as much as 50 years. Disposal near the coast at relatively shallow depths (20 to 100 m) in fjord basins, has been practiced in Norway and Canada. During the last 20 years more emphases have been on deep disposal (> 100 m depth), to make sure that the tailings are not influencing the euphotic zone (DSTP). The discharge takes normally place some distance off the coastline, on a slope at depths between 150 and 300 m and the tailing plume is moving along the bottom, down the slope to a deep water basin with depths beyond 1000m. This has particularly been the practise in countries like Indonesia, Philippines and Papua New Guinea (Jones and Ellis, 1995).

The objectives, both with respect to shallow and deep disposal, have been to dispose the tailings in a controlled manner, where the tailings settle within a predicted area. To promote a controlled dispersal of mine tailings in the sea, the technical design of the disposal infrastructure should include a mixing tank where the slurry containing tailing particles and freshwater is mixed with high saline sea water before the tailing is disposed in the sea. This increases the density of the tailing plume and maintains the homogeneous feature of the plume. Additionally, initial natural flocculation of fine tailing particles reduces the uncontrolled dispersal of fine tailing particles in the sea (Skei and Syvitski, 2013). Installation of a de-aeration unit on the tailing pipe to avoid that air bubbles in the tailing slurry carry small tailing particles to shallow water is necessary.

These are technical methods applied in modern sea disposal projects to minimize the environmental impact and to reduce the footprint on the sea bed. Even if these technical requirements are satisfied, there are still questions to be asked about the environmental feasibility of sea tailing disposal. Some of these questions are related to general concern and others are more site specific. In any case, a comprehensive Environmental Impact Assessment (EIA) is required where the impacts and risks of land disposal and sea disposal are compared.

Methods for Environmental Impact Assessment (EIA) of DSTP

The value of an EIA will often depend on available knowledge of DSTP in general and the site specific conditions, i.e. how suitable the selected site is for sea disposal. It is therefore of importance to critically study the fundamental knowledge about DSTP ahead of the EIA study. Critical gaps of knowledge should be filled by research and comprehensive base line studies of the selected disposal area are necessary. The experience so far with existing DSTP projects is that in many cases the importance of base line studies has been underestimated. Particularly natural variability. This has also negative consequences for the monitoring program, which is an important element in a DSTP project. The monitoring is supposed to validate the modelling and predictions made with respect to the behaviour and impact of the tailing, and the baseline investigations are the bench marks.

Consequently, an identification of critical gaps of knowledge (often based on FAQs) and design of a research program to fill these gaps is a fundamental platform for an EIA. Additionally, a base line study of the site which will be influenced by the disposal is necessary. In next generation mining projects both the research program and the base line study should be carried out in full transparency and published in the open literature.

There are many end users of EIAs, i.e. regulators and environmental decision makers, the mining industry, scientists, NGOs and other stakeholders. All require EIAs based on scientific documentation and understandable conclusions. Perception of the content of EIAs is very important and the challenge is to communicate scientific results with stakeholders and the public. An important element is to document the chemical, physical and toxicological properties of mine tailings to be able to distinguish tailings from waste products from other industry. The recovery of metals from sulphide ores using modern processing is often 98-99%, which implies that the tailings to a large extent is ground up rocks with elevated levels of metals and remnants of chemicals used during the processing. Processing chemicals known to be harmful to the environment should be phased out and replaced with more friendly chemicals. Consequently, the environmental risk related to the disposal of mine tailings on the sea bed is mainly related to the large volumes needed to be disposed in large scale mining operations. Smothering of the seabed by mineral material with no nutritional value to the bottom fauna has certainly a negative effect on the benthic ecology in the area where the rate of sedimentation by far exceeds the tolerable sedimentation rate with respect to bottom fauna. It is therefore important to design a disposal site with a minimum surface area.

The challenge of comparing impact on land and the sea

When impact is to be assessed it is important to consider the risk both in short and long terms, which also imply the potential of rehabilitation of disposal sites after termination of the mining operation.

A tailing dam on land has normally a water cover. What happens when the discharge of tailings to the dam ends depends on the local climate; whether the dam is located in an arid or high precipitation area. If the water cover is not maintained a dust problem occur and fine tailing particles will be transported by wind long distances. This may also cause a health problem. If the dam is in a high precipitation area the overflow of water may contaminate surface water and ground water used for other purposes. This is particularly a problem where the tailing contains high levels of sulphide minerals which are easily oxidized on land, causing low pH and elevated levels of dissolved metals.

Tailing disposed in the sea using BAT should stay on the seabed if the disposal site is a deposition site and not an erosional site. Biogeochemical processes may alter the stability of the minerals due to redox changes and the fluxes of metals at the sediment-water interphase may either increase or decrease by time. It is therefore important to do experimental work with tailings and how changes in redox influence the release of metals. When the mining operation has terminated the natural sedimentation of mineral particles and organic matter take over and gradually a new natural sediment substrate develops. It is important to measure by isotopes the natural rate of sedimentation at the disposal site to be able to predict how long it will take to cover up the tailings. In coastal and estuarine areas it has been observed that a new benthic fauna is established within a period of 10 years (Ellis, 2002). In the deep ocean it will take longer.

Acceptance criteria

An important issue with respect EIA studies is the concept of what is acceptable of environmental impact. Mine tailings vary in composition and environmental concern. Coarse, sandy tailings with low level of sulphide minerals represent less challenge than very fine grained tailings with a high sulphide and metal content. Therefore, the environmental risk should be based on a series of tests of the tailing composition and behaviour in sea water (sedimentation properties, release of metals from the mineral particles, toxic properties and the possibility of recollonization of the tailings with benthic fauna). Based on the outcome of these experiments, decisions should be made whether the tailing is acceptable for sea disposal. If not land disposal will be the alternative, if similar tests using freshwater show less negative effects. Another alternative is that the mining industry is able to change the processing of the ore, resulting in a tailing which is more compatible with marine sediment.

Conclusions

Mining waste should be managed in an environmental acceptable and a technical and economical feasible way. In next generation mining projects alternatives to traditional land disposal of tailings should be evaluated. Sea disposal is one alternative, assuming that the waste material is not causing a permanent damage of the marine environment. This will depend on the properties and behaviour of the waste, application of BAT for disposal and the suitability of the disposal site. A comprehensive baseline study, followed by EIA and a long term monitoring program will be the basis for decision.

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