EVALUATION OF TURKISH MINE WASTE MANAGEMENT POLICY WITH RESPECT TO MARINE POLLUTION

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ABSTRACT

Large volumes of wastes are produced by the mining activities and mine waste management is one of the most important environmental issues which directly affect the feasibility of the mine related to permitting. The slurries or waste materials left over after mineral is extracted from ore via physico-chemical processing are called tailings which must be safely disposed to prevent the release of contaminates into the environment. Tailings are generally stored onland surface impoundments; can be used in backfilling the voids in exhausted underground mines and/or transferred through pipes and disposed to a watercourse under the water level subaqueously. In deep sea tailings placement (DSTP) method, the tailings are disposed to deep sea zones far from the shore. The environmental legislations are improving, forcing the mining industry to take strict measures regarding tailings management. The Turkish Regulation on Mining Wastes have been published in 2015 and is going to be in force by July 15, 2017 where DSTP is adressed as a possibility for non-hazardous wastes disposed to anoxic layer of Black Sea. This manuscript aims to provide guidance on the environmental permitting of DSTP practices as an option in Turkey's Legislation.

KEYWORDS:
Tailings, Deep Sea Tailings Placement (DSTP), Mine Waste Management, Marine Pollution.

INTRODUCTION

The extraction of metals and minerals through mining of geological resources aims to improve the quality of civilization however, the management of the residues generated at mining operations, mainly the tailings and waste-rock remains as the most important environmental issues on permitting [1, 2, 3, 4]. Potential environmental issues associated to mining activities other than wastes are air quality including dustfall [5], water use and quality, hazardous materials, land use and biodiversity, noise and vibrations energy use and visual impacts [6, 7]. Figure 1 shows the typical operations in mining.

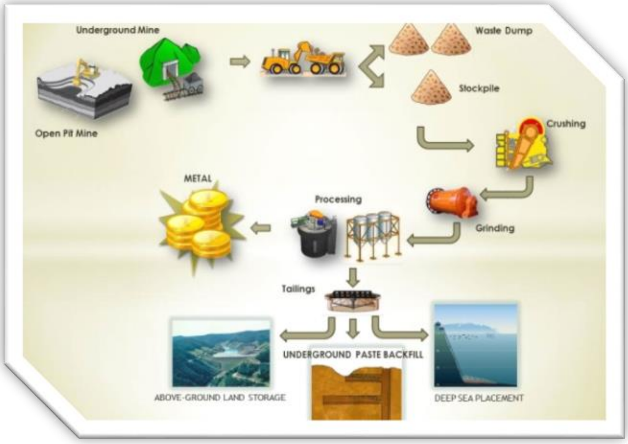

FIGURE 1
General Flow Scheme for Mining [8]

Tailings may contain suspended solid particles consisting of economically worthless minerals and a small amount of valuable minerals, dissolved solids, metal ions, chemical reactives and reaction products [9]. The heavy metals, which are important in terms of environmental pollution, contained in tailings are listed as: Boron (B), Cadmium (Cd), Chromium (Cr), Berilium (Be), Antimony (Sb), Silver (Ag), Arsenic (As), Lead (Pb), Mercury (Hg), Manganese (Mn), Nickel (Ni), Selenium (Se), Titanium (T), Uranium (U), Vanadium (V), Zinc (Zn) and Aluminum (AI) and other environmental problems encountered are the Metal Leach (ML) and Acid Rock Drainage (ARD) [9, 10, 11].

The disposal methods of tailings vary on the basis of cost, environmental factors and structural risks *i.e.* failure [1, 3]:

- On-Land disposal: Storage of tailings in dams and ponds (Tailings Storage Facility - TSF).
- Backfilling in underground mines: Filling the spaces left after ore extraction in underground mines with paste fill (dehydrated cement added dry sludge) ensures both reinforcement and waste disposal simultaneously.
- Discharge to Surface waters: Tailings disposal to the river courses is abandoned due to its environmental impacts on surface water resources [3, 12]. In USA and Canada, the disposals to lakes are being ceased due to low assimilation capacity in closed systems. In deep sea tailings placement (DSTP) method, the tailings are disposed to deep sea

zones far from the shore. It is applied in regions, where the sea is deep and close to the facility, the precipitation is high and evaporation is low, and where the land disposal methods of tailings are risky due to the stability and seismicity problems.

As of 2012, there have been approximately 3,500 TSFs in the world and until that date, significant failures have been encountered in 138 storage facilities [12]. The examples are: In 2010, due to the failure of the embankment in Hungary, 600,000-700,000 m^3 tailings have spread to the region and caused the death of 10 people. In 1998, the failure in the TSF of Los Frailes Mine, Aznalcollar region of Spain, caused 5-7 Mm^3 tailings have flown to Rio Agrio River and raised the river bed with 3 m and covered 3,500 ha of agricultural area. In 1985, TSF failure in Stava, Italy, caused the death of 268 people [1, 12].

Over the last century the volumes of tailings being generated has grown dramatically as the demand for minerals and metals has increased and lower grades of ore are being mined through advances in extraction and processing technology [13]. Being different from other industrial wastes, the tailings are produced in very big amounts. There are individual mines producing in excess of 200,000 tonnes of tailings per day [13]. Approximately 100,000 ML of postprocessing tailings slurry of the Lihr Mine on Niolam Island in Papua New Guinea is deposited annually at depth from a sub-surface pipeline (DSTP) [14]. The DSTPs are in operation in Norway with discharges from 300 000 to 4 million tons/year, where mining tailings have been deposited at 17 fjord- or near-coastal sites in Norway [2].

According to Eurostat statistics, the mining and quarrying industry produced 671,810,000 tonnes of waste in 2010, in EU (27 Member States-MS) which is equivalent to around 30% of the total waste generated in the same countries [15]. The EU (28 MS) produced over 730 million tonnes of mining waste in 2012, where 13.7 million tonnes of it is hazardous waste contribution [15].

Since tailings generally contain compounds with sulfide, they must be covered with water or an appropriate impermeable material in order to prevent their contact with air and occurrence of ARD and ML at the stage of mine closure [1, 3]. Among the important impacts related with the TSF, loss of land and habitat due to their large footprint areas, impacts on surface and underground waters and visual impacts can be mentioned. The engineering studies performed in order to ensure the short and long period stability of civil structures are among the most important issues in TSF planning.

TABLE 1
Applications of DSTP in the World as of 2012 [18]

Water environment of discharge	Mine area	Mine production	Firm
Basamuk (Astrolabe) Gulf, Bismarck Sea	Ramu Nickel and Yandera mines, Papua New Guinea	nickel-cobalt; copper- gold	Metallurgical Construction Corp., Highlands Pacific (Ramu); Marengo Mining (Yandera)
Norway fiords	Kirkenes, Kvannevann, Stjernøya, Hustadmarmor Skaland, Engebøfjellet, Repparfjorden	Iron, industrial minerals, titanium, copper	Northern Iron Ltd., LNS AS, Sibelco Nordic, Omya Group, Nordic Mining, Nussir
Senunu gulf	Batu Hijau mine, Indonesia	Copper – gold	Newmont Mining, Sumitomo Mining
Luise port	Lihir mine, Papua New Guinea	Gold	Newcrest Mining
Pigiput gulf	Simberi mine, Papua New Guinea	Gold	Allied Gold
Black Sea	Çayeli Bakır, Türkiye	Copper – zinc	Cayeli Bakir Isletmeleri A.S.

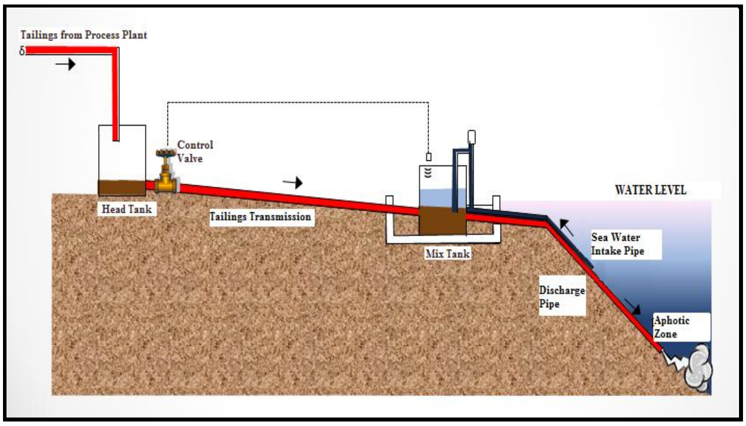

FIGURE 2
Typical DSTP Structure

The DSTP targets the trapping of tailings at the bottom of deep sea. The tailings are transported from the facility to the deep-sea environment through pipes, and discharged in the deep layer, below picnocline [10, 11, 12, 13, 14, 16, 17]. Typical DSTP structure is given in Figure 2.

The most important environmental impacts of DSTP are (i) the loss of benthic habitat on the footprint, where the tailings are stored at the sea bottom, (ii) the impacts on abundance and diversity of species, and (iii) the risk of bio-accumulation of heavy metals in the food chain.

As of 2012, there are 11 mines using the DSTP method in the world (Table 1) and all of them have obtained the legal permissions from the competent authorities in host countries. [12, 18]:

- 5 mines in Norway,
- 1 mine in England,
- 1 mine in Turkey,
- 1 Mine in Indonesia,
- 3 mines in Papua New Ginea.

The historical development of DSTP method, which has been commenced approximately 40 years ago in Philippines and Canada shows that the applications performed without mineralogical, geo-chemical and oceanographic characterization, can cause damage to the environment [11, 12]. Environmental impact from sea tailings disposal appears the lack of baseline information on the habitat, environmental conditions, and associated microbial and faunal components that are affected by the discharges. There is also a lack of scientific knowledge of the biodiversity patterns and functioning of the marine ecosystems, particularly in the deep-sea, as well as of effects of metals and chemicals on deep-sea biota [3].

Especially due to its advantages such as prevention of ARD risk by the wastes containing sulfite; in cases of construction of land based TSFs that are not geo-technically suitable; and prevention of land losses, DSTP is accepted as an alternative for the techniques of land disposal systems [1, 3].

MATERIALS AND METHOD

Assessment of International Legislation on DSTP. The evaluation of international legislation is based on the performance criteria published by World Bank's International Finance Corporation (IFC) [6, 7] and the European Union (EU) directives [19] within the framework of harmonization works in the membership process of Turkey. Besides, there are international agreements and protocols signed for the protection of seas surrounding Turkey.

Mining Wastes. EU mining waste management includes one directive (Directive 2006/21/EC on the management of waste from extractive industries - the Mining Waste Directive- "MWD") and 5 decisions in relation to the implementation of MWD [19]:

- 2009/360/EC completing the technical requirements for waste characterization;
- 2009/359/EC on the Definition of inert waste in implementation of Article 22 (1)(f),009;
- 2009/337/EC on the Criteria for the classification of waste facilities in accordance with Annex III;
- 2009/335/EC on the Technical guidelines for the establishment of the financial guarantee;
- 2009/358/EC on the Harmonization, the regular transmission of the information and the questionnaire referred to in Articles 22(1) (a) and 18.

Other relevant EU directives are listed as:

- 2012/18/EU On the control of major-accident hazards involving dangerous substances (Seveso III),
- 2010/75/EU On industrial emissions (integrated pollution prevention and control-IPPC),
- 2008/98/ EC on waste and repealing certain Directives on waste (Waste Framework Directive).

Directive 2004/35/EC on environmental liability with regard to the prevention and remedying of environmental damage (ELD) came into force in 2007 introducing the "polluter pays" principle [4]. A holder of an IPPC or waste licence for mining and related waste activities in the EU is subject to the ELD because many mining related activities are listed in Annex III of it [4].

The EU's waste management approach is based on the "waste hierarchy" which sets the following priority order for policy development: prevention [20, 21], (preparing for) reuse, recycling, recovery and, as the least preferred option, disposal (which includes landfilling and incineration without energy recovery) [19].

TSFs are divided into two categories as "Category A" and "Non-Category A" in accordance with the risk they have on public health and environment in EU Waste Legislation. For a tailings facility to be considered as Category A, (i) the effects of the accidents that may occur in the facility must be at significant levels as the result of the risk assessment; or (ii) it contains waste classified as hazardous under Directive 91/689/EEC; or (iii) it contains substances or preparations classified as dangerous under Directives 67/548/EEC or 1999/45/EC.

Additional to the Directive 2006/21/EC, EU environmental legislation includes a Best Available Techniques (BAT) reference document for the management of tailings and waste-rock in mining ctivities known as BREF (2009). DSTP operations are included within the BREF (2009) [1] suggesting it as an acceptable method for mining areas where tailings are likely to generate ARD. As a BAT example, Hustadmarmor Calcium Carbonate Mine in Norway is presented where the driving force is the lack of space for tailings deposition on land.

World Bank's IFC grants loans for private sector projects and requires Environmental and Social

Impact Assessment (ESIA) and the application of "IFC Performance Standards" in the management of environmental risks and impacts in investments. For making use of IFC financing, the project is expected to be compliant with international good sector applications, which are recognized worldwide, such as Environment, Health and Safety Guides of the World Bank Group (EHS guides). In case host country regulations are different from those indicated in EHS Guides, the project owner has to comply with the stricter one. However, where necessary, the project owner may propose alternative mitigations and measures together with the relevant scientific evidences within the ESIA process [6].

IFC also issued sectoral EHS Guidelines (2007) where DSTP may be considered as an alternative only in the absence of an environmentally and socially sound land-based alternative and based on an independent scientific impact assessment for mining [7]. If and when DSTP is considered, such consideration should be based on detailed feasibility and ESIA of all tailings management alternatives, and only if the impact assessment demonstrates that the discharge is not likely to have significant adverse effects on marine and coastal resources, or on local communities. In accordance with IFC guidelines, for DSTP to be applied the possible impacts on the sea environments and the precautions to be taken against them must be compliant with international agreements such as the United Nations Convention on the Law of the Sea (UNCLOS), 1982.

Water Quality. The basis of the EU legislation on water quality consists of Water Framework Directive (WFD) numbered 2000/60/EC [19], which also has priority in harmonization of Turkish Legislation for this sector. WFD prescribes the protection and recovery of all water masses in EU in terms of quality and amount and targets to bring all underground and surface waters to the good status as of 2015 and eliminating hazardous materials with priority from the European watercourses. Directive on Environmental Quality Standards (2008/105/EC), which is also known as the Priority Substances Directive has been enforced to reach this target. The Directive on Pollution Caused by Certain Dangerous Substances Discharged into the Aquatic Environment of the Community (76/464/EEC) has been codified and adopted as 2006/11/EC.

WFD's combined approach icludes limiting pollution at the source by the setting of emission controls with relevant legislation (i.e. Urban Waste Water Treatment Directive, the Nitrates Directive and the IPPC Directive) and by establishing water quality objectives for watercourses in compliance with good status objective [22]. The river basin management plans and programmes are at the core of all water-related legislation. Watercourses used for drinking water purposes will be subject to particular protection, linked to a requirement of complementary standards and measures to ensure safe drinking water supply, ensuring the standards of the Drinking Water Directive are met [22].

Marine Strategy Framework Directive (MSFD) (2008/56/EC) [19] has entered force in 2008. It targets to create the necessary information and application tools in line with the "Ecosystem Approach" for the transition-coastal and coastal-sea waters to ensure "Good Environmental Status" in EU marine waters until 2020 promoting international cooperation through Regional Sea Conventions (RSC):

- The Convention for the Protection of the Marine Environment in the North-East Atlantic of 1992 (further to earlier versions of 1972 and 1974) – the OSPAR Convention (OSPAR),
- The Convention on the Protection of the Marine Environment in the Baltic Sea Area of 1992 (further to the earlier version of 1974) – the Helsinki Convention (HELCOM),
- The Convention for the Protection of Marine Environment and the Coastal Region of the Mediterranean of 1995 (further to the earlier version of 1976) – the Barcelona Convention (UNEP-MAP),
- The Convention for the Protection of the Black Sea of 1992 – the Bucharest Convention.

The most important international agreements on waste disposal to the seas are: "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention, 1972)", its amendment in 1978 and London Protocol (1996). The London Protocol has been signed by 45 nations including Australia, New Zealand and Philippines [23]. Turkey is in the process of becoming a party to those agreements [24].

The purpose of London Convention is to control all marine pollution sources and to prevent marine pollution by regulating the dumping of wastes to the sea. The "gray list" and "black list" definitions are made for the wastes to categorize them in accordance with the hazard they cause in terms of environment. While the disposal of the materials in the black list is completely prohibited, the disposal of the materials in the gray list is subject to special permission from the competent authority of the host country and in compliance with certain conditions. For the disposal of other materials, a general permission is sufficient.

The London Protocol is more restrictive than London Convention. The disposal of any kind of materials except the materials included in the annex of the Protocol, or their combustion on the sea, has been prohibited. Although the sea disposal of "inert, inorganic geological material" is permitted in the protocol, tailings are not assessed within this scope. Technically, the protocol regulates the rules of dumping at the seas, platforms etc on the sea rather than the discharges to be made from the land.

Evaluation of Republic of Turkey's Legislation on DSTP. An Environmental Impact Assessment (EIA) permit is the first environmental permit required for new mining operations, as well as for major mine operation modifications. The EIA permit acts as a temporary permit for the construction of the mine. Within one year after start of the operation a Temporary Environmental Operation License application has to be made to Ministry of Environment and Urbanization (MEU). Following the application, compliance testing via an accredited laboratory is conducted for mine emissions and discharges and then "Final Environmental Operation License" is issued. The environmental licenses are managed by the MEU and cover all aspects of the environment including but not limited to waste water discharge, air pollutant emissions, noise, solid waste, hazardous waste.

Mining Waste. In line with the MWD, the MEU, published the "Regulation on Mining Wastes (RMW) (Official Gazette Date: 15.07.2015; Number: 29417). Also, Regulation on Waste Management (RWM) (Official Gazette Date: 02.04.2015; Number: 29314) has been completely harmonized with EU.

RMW classifies mining wastes in three classes as "hazardous", "non-hazardous" and "inert" wastes and addresses RWM for determination of hazardousness in which, Annex-4 provides list of wastes including mining, Annex-3/A provides the hazardousness properties and Annex-3/B provides the limit values as references for their characterization. For the determination of the geochemical properties of the waste and for the determination of ARD and ML risk, the static and kinetic tests are requested.

Leachate management is one of the most serious issues in landfill operation [25] where the leachate characterization is conducted according to the Regulation on Landfill (RL) (Official Gazette Date: 26.03.2010; Number: 27533). The land deposition of tailings in impervious impondments was subject to RL till to the enforcement of RMW.

The sea disposal of mining waste is included in Article 22 of the RMW and the conditions to comply with are defined as follows:

- As a result of waste characterization, mineral wastes which are defined as hazardous can not be disposed in the seas surrounding Turkey. Only inert and non-hazardous mineral wastes can be disposed in the anoxic layer of the Black Sea.
- There should be no geographical, topographical and geologically appropriate area in the terrestrial zone within an approximate radius of 30 km of the mine having inert and non-hazardous mineral wastes to dispose those tailings to Black Sea.
- A scientific report must be submitted to MEU representing the oceanographic and hydrodynamic conditions at the discharge location, assimilation capacity of the sea, behaviour of discharge plume and its impact on ecology and water quality.
- The receiving environment will be monitored seasonally-four times in a year for the following parameters: temperature, salinity, light transmittance, density, electrical conductivity, chlorophyll-a, pH, dissolved oxygen, hydrogen-sulfur, alkalinity, copper, zinc, mercury, lead, iron, manganese, cadmium, arsenic, total suspended solids, total organic carbon, crude oil and its derivatives. Additional parameters are required if MEU deems necessary.

For the new developing mining projects, Waste Management Plan has to be prepared in the EIA process in compliance to the RMW.

Water Quality. Turkey has announced that full harmonization of WFD under the "Environment" section and its adherence to the cited Conventions will take place following full membership of the EU and that full harmonization with the Directives under the Treaties can be done two years before the date of EU membership is finalized [24].

Regulation of Water Pollution Control (RWPC) being the most important legislation applied in the protection water resources is first issued in 1988, and the current one has been in force since 2004 (Official Gazette Date: 31.12.2004; Number: 25687). According to RWPC, the discharge standards were determined on a technological basis, each water mass was assumed to be the same and the same discharge standards were applied.

The principles related with the deep-sea discharge of the wastewaters are defined in RWPC and the criteria are established in accordance with the domestic wastewater properties. Direct discharges to the receiving environment of any kind of solid wastes, and sludge are prohibited. The dredging and disposal of the dredged materials are subject to permit of the MEU. There is a circular of MEU (2014/7) which defines the principles of deep sea discharge project preparation.

The regulatory harmonization works within the scope of marine/coastal waters performed by the Ministry of Forests and Water Affairs (MFWA) and MEU are summarized in the following pharagraphs [26].

- Regulation on Management of Surface Water Quality (RMSWQ) (Official Gazette Date: 30.11.2012; Number: 28483) has been issued targetting to identify and classify the biophysicochemical and hydromorphological qualities of surface, coastal and transitional waters; and to establish the principles and procedures for the mitigation measures to be taken to achieve good water status. By the publication of the the water quality classification articles of RWPC have been repealed.
- The chemical substances listed in Annex-1 and Annex-2 of Regulation on the Control of Pollution of Water and its Surroundings Due to Hazardous Substances (Official Gazette Date: 26.11.2005; Number: 26005) has been updated and harmonized

in 2010 (Amendment Date: 30/3/2010-No:27537).

- In order to obtain good water status, the existing quality of the water masses has to be determined as well as their quantities. It is important to establish the National Monitoring Network and to perform monitoring in an integrated way to perform monitoring within the scope of WFD. To comply with the requirements of WFD, the Regulation on the Monitoring of Surface and Underground Waters (RMSUW), which includes the procedures and principles related with the monitoring of water quality has been issued (Official Gazette Date: 11.02.2014; Number: 289105).
- The harmonization works for the Directive on the Management of Bathing Water Quality (2006/7/EC) are being performed jointly by the MEU and MFWA under the coordination of Ministry of Health (MH).

In addition to all the above legislation, the provisions of the Law on Coast (LC) numbered 3621, the Regulation on the Implementation of the Law on Coasts (RILC) (Official Gazette: 3.08.1990; Number: 20594) and the Notification on the Planning and Application Process for Coastal Structures and Facilities (NPAPCSF) (Official Gazette: 06.07.2011; Number: 27986) have to be complied with. The NPAPCSF requires, "Hydrographic and Oceanographic Report" approved by Naval Forces Command (NFC) Navigation, Hydrography and Oceanography Department.

Any mine that discharges process water into a watercourse requires discharge licence accordance to the Regulation on Environmental Permits and Licenses (Official Gazette: 10.09.2014 Number: 29115). In Turkish Legislation, it is stated clearly that discharges from waste management activities at mine sites has to be controlled in a manner that causes no deterioration to local water quality both surface waters and groundwater. The provincial directorate of Ministry of Food, Agriculture and Husbandary is included in the environmental permitting process under the Law on Water Products numbered 1380.

TECHNICAL STUDIES ON DSTP DESIGN

Since the tailings plume is heavier than the sea water, its buoyancy flux has a negative value and the plume will have the tendency of precipitating at the sea bottom. The potential impacts of DSTP depend on the receiving environment conditions as a result of the interaction of biogeochemical, ecological, bathimetric and oceanographic properties with each other [10, 11, 12, 13, 14]. For instance, in the upwelling systems, the contaminants in the tailings plume will be transported from bottom to surface therefore negative impact on fishing, and deterioration of coastal water quality is unavoidable. The potential environmental impacts of DSTP are listed as, (i) the loss of habitat at sea bottom ecosystem due to the stored footprint area of tailings, (ii) impact on the deep-sea organisms due to the metal toxicity and chemical processes which leads bio-accumulation in the food chain. Therefore, the tailings characterization and determination of the background oceanographic properties of the marine environment are the basic factors for the impact assessment of DSTP practice [11].

Water column measurements of CTD (Conductivity/ Tempretature/ Density) and sea-current have to be conducted in order to establish the hydrodynamics of the sea environment and to predict the behavior of the discharge plume [27, 28]. In addition to the oceanographic measurements, the hydrodynamic loads have to be calculated and the structural behavior against those loads has to be assessed for the design of submarine pipelines [29]. The wave and current climate has to be conducted in accordance with the measurements and meteorological data, the design wave and current properties have to be determined and hydrodynamic forces that will act on the structure have to be calculated [29]. Transportation and sinking analysis, tension and deformation analysis of the pipeline and the geological and geophysical studies have to be performed [29].

The deep sea outfall design of tailings and the domestic wastewater outfall design have different principles. In the domestic wastewater case, the outlet of the discharge, which has jet flow, through small diameter diffusers is preferred to ensure a high primary dilution (near-field dilution) with momentum principles. The waste plume, which has the tendency of rising due to its density that is lower than sea water, is subject to secondary dilution with the effect of the currents and tertiary dilution in terms of bacterial decay. The tailings include mineral solids, therefore the risk of clogging of small holes is high, and therefore the use of diffusers is not possible. A modeling study has to be performed to make predictions related with the post-discharge waste behavior.

The first phase of the post-discharge behavior of tailings consists of the near-field intense current model. The purpose of this first phase model is to simulate the behavior of the discharge plume, which creates a current due to density, after leaving the pipe, within small grids depending on the pipe diameter [28, 29].

The second phase of the discharge plume fol-

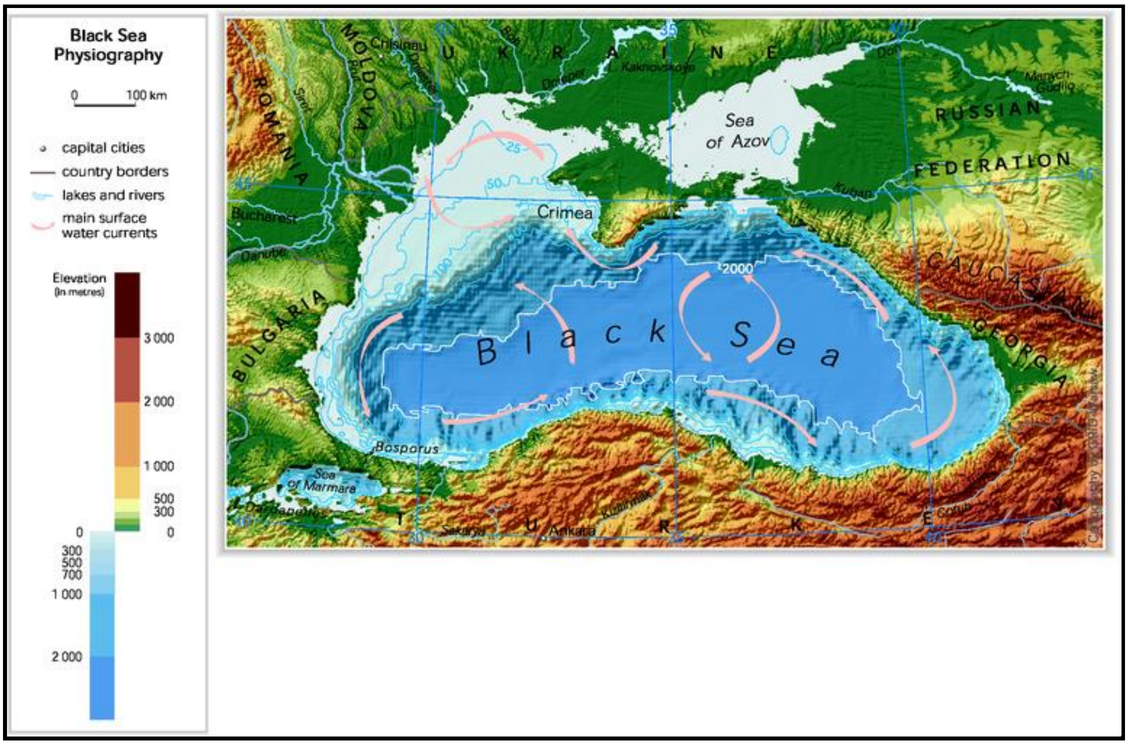

FIGURE 3
Physiography of Black Sea (http://www.eea.europa.eu/legal/copyright) [30]

lows that heavier solid particles remain in dense flow and settle after being carried to far distances by gravity and bottom slope. This behavior is simulated within bigger grids with the far–field dense current model. Lighter particles leave the dense current plume and constitute separate plumes at depths, where the medium density is the same as the density of that fluid. Consequently, the dense current containing heavy particles act as the continuity of the discharge pipe carrying the materials to deeper zones [28, 29].

Measurement of physical and biogeochemical parameters in the water column and in the sediment is important for DSTP design and for monitoring the post discharge conditions. The monitoring programme to control the environmental impact inside and around the deposit area usually covers the following parameters [1, 3]:

- water column analyses on solids content (turbidity), salinity, oxygen content and temperature, trace metals and chemicles accociated with the tailings composition,
- sediment analyses *i.e.* trace metals and chemicles accociated with the tailings composition,
- biological activity,
- bioaccumulation to analyse potential toxicity to aquatic and benthic life;
- annual video recording of the underwater pipeline and discharge point in order to observe any structural failure risks. In deep waters, where diving is risky and dangerous, ROV (remotely controlled underwater vehicle) can be used.

GENERAL PROPERTIES OF BLACK SEA

The RMW addresses DSTP applications to Black Sea on special circumstances. Black Sea is a semi enclosed sea and is connected to the Mediterranean Sea through Istanbul and Çanakkale straits and to the Azov Sea through Kerch strait (Figure 3).

Black Sea basin is receiving an abundant amount of rain. The amount of rain increases from the west towards the east and reaches an annual value of 2500 mm [31]. The main components of water balance consist of the rivers, rain and the water coming from the straits and evaporation and the water exiting through the straits. The waters are anoxic after a depth of 150 – 200 meters [31, 32].

The most important property of Black Sea, which makes it different from other seas, is that the deep basin waters are always anoxic and contain hydrogen sulfur (H_2S) in high concentrations, which increase towards the bottom [31, 32]. The basic reason of this formation is the separation of the Mediterranean Sea waters filling the entire bottom basin (>22 ppt) from the lower saline waters at the surface (18 ppt) [32]. The vertical mixtures in the Black Sea are effective up to the upper limit of halocline. Therefore, the transportation of dissolved oxygen from the oxygenated surface layer to the sulfur containing deep waters is very limited [32, 33].

Since the oxygen input does not meet the oxygen need of the aerobic bacteria, the disintegration of the precipitating organic material occurs as the result of sulfate (SO_4^{2-}) reduction by the anerobic bacteria and an environment with H_2S occurs. In Black Sea ecosystem, the starting border of waters with H_2S is 90 – 100 m in open waters, where cyclonic eddies dominate and 160-180 m at the coasts [32]. The basic circulation on the Black Sea basin is defined with cyclonic eddies in the center; anti-cyclonic eddies along the periphery and anti-cyclonic Batum Eddie at the eastern end, surrounded by the Rim Current [34].

The limiting values of "Trophic Levels of Surface Water Masses" provided for Black Sea and Marmara in Annex-7 of the Regulation on Surface Water Quality Management, are given in Table 2.

TABLE 2
Eutrophication Criteria for Black Sea and Marmara Sea Coastal and Transition Waters (RSWM, Annex-7)

Water Quality Class	DIN (μg/l)	TP (μg/l)	Chl a (μg/l)	Secchi Disk(m)
Oligotrophic	<20	<15	<0.7	>6
Mesotrophic	20-140	15-30	0.7-3	3-6
Eutrophic	141-250	31-40	3.1-5	1.5-2.9
Hypertrophic	>250	>40	>5	<1.5

DIN: (nitrate + nitrite + ammonium)- represent the total Dissolved Nitrogen.

CONCLUSIONS

The waste management strategy has to be based on methods, which will not pose any risks on the public health and safety, where the social and environmental impacts remain within acceptable limits. As recommended in the EU legislation and IFC Standards, DSTP method can be used by researching all disposal methods scientifically with a full analysis and risk assessment. In regions where the sea is close and deep, precipitation is high, vaporization is low and land waste disposal methods are risky, DSTP method provides more advantages in comparison with other methods. Another advantage of DSTP method is the prevention of ARD and ML formation for tailings containing sulfur. The factors creating risks for the ecosystem can be eliminated with the discharge of tailings in aphotic and anoxic deep layer, where there is no upwelling.

Since the tailings discharge is heavier than the sea water, its buoyancy flux has a negative value and the discharge plume has the tendency of sinking on the sea bottom. The potential impacts of DSTP applications depend on the environmentalconditions to a great extent as the result of the interaction of the biogeochemical, ecologic, bathymetric and oceanographic properties with each other. Hence, the receiving environment quality standards have to be assessed differently in each sea region. The seas surrounding Turkey have unique biogeochemical properties that are different from each other:

- In Mediterranean Sea nutrient input is limited. The transportation with rivers in coastal areas is more effective in Western Mediterranean Sea. In Eastern Mediterranean Sea, especially on open waters, the only resource is the bottom waters, which are relatively rich in nutrients. Very strong vertical mixtures are observed in the deep basins due to the dynamic structure of Eastern Mediterranean Sea and because of the climatic conditions, and oxygen exists down to the bottom of the water column even in the deepest regions due to the effectiveness of vertical mixture [33].
- Aegean Sea basin, which is in the northeast of Mediterranean Sea, remains generally within oligotrophic limits; however, it can have more eutrophic properties in comparison with Mediterranean Sea with the effect of Black Sea waters in the north [33].
- Marmara Sea and the straits have a two – layer ecosystem. The low saline waters coming from the Black Sea are in the upper water column of 15-20 m, while the Mediterranean Sea waters entering from Çanakkale are in the bottom basin [33].
- Black Sea basin is receiving an enormous amount of rain. The amount of rain increases from the west towards the east and reaches an annual value of 2500 mm [32, 33]. The most important property of Black Sea, which makes it different from other seas, is that the deep basin waters under the oxygenated surface layer are always anoxic and contain H_2S in high concentrations, which increase towards the bottom [32, 33]. The basic reason of this formation is the separation of the Mediterranean Sea waters filling the entire bottom basin (>22 ppt) from the lower saline waters at the surface (18 ppt) [32, 33]. The vertical mixtures in the Black Sea are effective up to the upper limit of halocline. Therefore, the transportation of dissolved oxygen from the oxygen containing surface layer to the sulfur containing deep waters is very limited.

When the biogeochemical properties of the seas of our country are taken into consideration in terms of DSTP application Black Sea has an important advantage due to lack of biological life in anoxic deep bottom waters containing high concentrations of H_2S. The formation of sediments due to the reaction of dissolved metals in the H_2S containing anoxic layer provides an advantage in terms of their limited mobility in the water column. The impact on habitat will unlikely to occur due to tailinds disposal within the anoxic layer since there is no biological life. However structural risks regarding the submerged pipeline remain inherent and must be assessed cautiously and in detail.

In Mediterranean and Aegean seas any DSTP practice may have drastic impacts due to the complex oceanographic and hydrodynamic properties of those marine systems.

The method of tailings disposal is decided in accordance with the economic and technical feasibility factors as well as the assessment of their environmental impacts and risks so as to include the period after the closure of the mine. DSTP practices have to be supported with scientific studies and must pass through very detailed assessment processes.

MEU is the coordinating authority for DSTP permits however there are quite a few governmental institutions to be consulted officially that the interactions and the duration of permitting process can not be foreseen in Turkey's environmental legislative framework which may hinder the mining.

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