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THE ENVIRONMENTAL EFFECTS OF WASTE WATER EMANATION FROM SULPHUR MINING ON WATER RESOURCES

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ABSTRACT

Mishraq sulphur mine is situated in the northern part of Iraq about 40 km south of Mosul .
The Frasch process is adopted to produce raw sulphur by injection of hot and compressed air.Hot water is channelled through the ground layers,causing the escape of mining hot-water carrying large quantities of sulphides,BOD,and suspended solids to ground water within the area as well as to Tigris river .
Three types of wastewater are produced from the purification processes. Wastewater released from debitumenization unit after treatment of raw sulphur with sulphuric acid,wastewater released from filtration units after treatment with tonsil and the leachate of solid waste produced from both processes.These wastewaters are highly acidic containing large quantities of suspended and dissolved organic solids.The first two wastewaters are discharged to a large pool prior to disposal to Tigris river. However,the seepage of leachate from the disposal site carries pollutants to the ground water .

INTRODUCATION

Mishraq sulphur mine is considered as one of the biggest sulphur deposits in the world;it is situated in the northern part of Iraq,about 40 km south of the city of Mosul, Fig.(1). The extraction of these deposits is considered to be economically feasible (1) .
The mine rises about 70m above the neighbouring river level,and declines towards the river with a steep cliff.
The water of the deposit series is highly mineralized, and the general mineralization of this water ranges from 4500-6350 mg/l; this water contains amounts of sulphuretted hydrogen ranging from 99.0 - 482 mg/l H_2S .
The Outflow of natural gas was observed at some holes and the odour of H_2S is commonly inhaled when drilling the deposit series.
Rocks of the sulphur deposit series are strongly bituminous.The occurrence of these bituminous materials causes lots of difficulties during the process of drilling.
Large quantities of waste water are pumped directly into the Tigris river with suspended solids.
Three types of waste water were identified,which are mainly produced from the purification process : the first type is the waste water which is released from debitumenization unit after treatment of raw sulphur;the 2nd waste water is released from filtration units after treatment with tonsil;and the 3rd type is the leachate of solidwaste produced from both processes.These waste waters are highly acidic containing large quantities of suspended and dissolved organic solids .

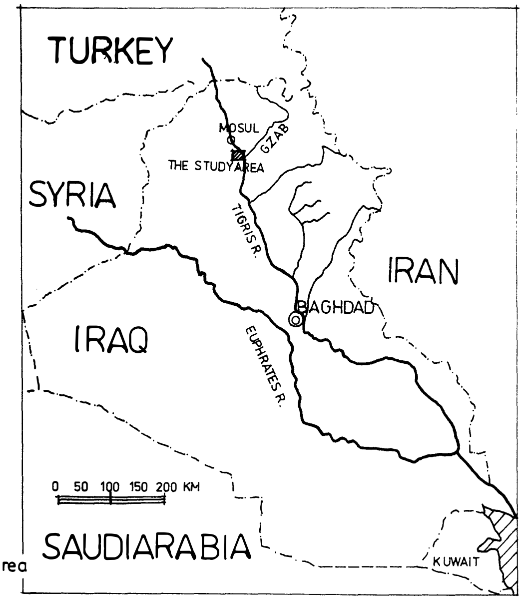


Fig.1 Location of study area

SOURCES OF WASTE IN MISHRAK COMPLEX

The sulphur complex at Mishrak has adopted Frasch process to produce sulphur. Crude molten sulphur obtained by this method is contaminated with about 1 to 2% by weight bitumenous material,which lowers its quality and renders it unsuitable for industrial and agricultural uses.

The wastewater emanating from this complex results from the operational processes used to upgrade the sulphur quality.

The complex consists of four production areas.Each area releases waste water carrying different types of pollutants, depending on the nature of operational units.

In the 1st area,large quantities of water are drawn by huge pumps erected directly on Tigris river.Suspended solids and hardness are removed through the clarification processes.The wastewater resulting from these processes, which is highly alkaline and containing large quantities of suspended solids, is disposed directly to the river down-stream from the pumping station.

In the 2nd area, water coming from the 1st area is further treated to remove remaining hardness and to eliminate dissolved oxygen for protection of pipes and equipment from corrosion. Wastewater from the regeneration process of ion exchangers is discharged to groundwater,carrying with it large quantities of calcium,magnesium and chloride ions.

Frasch process is adopted to produce raw sulphur by injection of hot and compressed air in the 3rd area. Hot-water channeling occurs through the ground layers, causing the escape of mining hot-water carrying large quantities of sulphides, BOD and suspended solids to Tigris river and groundwater .

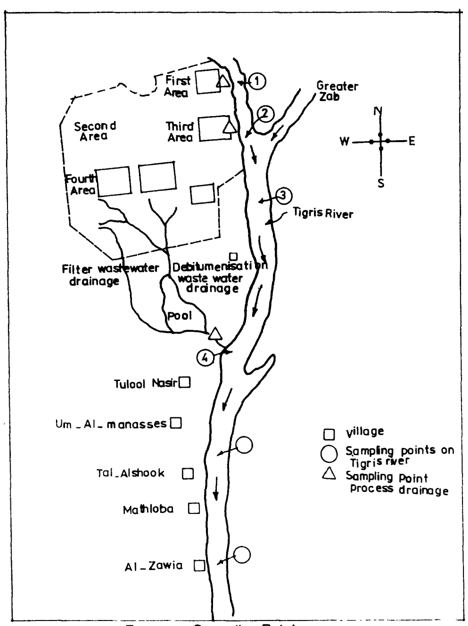
Three types of wastewater are produced from the purification processes in the 4th area . Wastewater released from debitumenization unit after treatment of raw sulphur with sulphuric acid,wastewater released from filtration units after treatment with tonsil and the leachate of solidwaste produced from both processes.These wastewaters are highly acidic, containing large quantities of suspended and dissolved organic solids.The first two wastewaters are discharged in a large pool prior to disposal to Tigris river.However,the seepage of leachate from the disposal site carries pollutants to the groundwater .

MATERIALS AND METHODS

A sampling programme extending from September 1984 to August 1985 was planned out .It is reasonable to presume that this period would include most of the variations in Tigris-river water quality and flow.Samples were collected monthly from specified points located sufficiently downstream from the sites of pollutant discharge to ensure dispersion through the cross section of the river .

Another programme was adopted to collect selected samples from the wells distributed in the villages located around the industrial site.Three samples were collected from each well through the mentioned period for quality analysis .

Samples of wastewater released from clarification , mining,purification processes and leachate of solidwaste were collected also.Figure(2)shows the sampling points considered in this work.Physical quality factors of temperature,total dissolved solids, suspended solids,and chemical quality parameters of ph,total hardness,sulphide, sulphate and BOD were performed according to the standard methods (2).These analyses were chosen in such a way to serve as a guide to evaluate the environmental impact of sulphur industry on the quality of water resources in Mishrak .



Fig(2) SamplingPoints

RESULTS AND DISCUSSION

SOURCES OF POLLUTANT

Before discussing the quality changes in water resources,along the Mishrak area,it is of great importance to have some knowledge about the characteristics of wastewater released from each area .Table(1) shows the concentrations of pollutants discharged from the different areas .

It is clear that the wastewater released from the 1st area was highly alkaline with large quantities of suspended solids and considerable amounts of total dissolved solids and sulphate.The wide variation noticed in the concentration of suspended solids is due to the side product evolved from the clarification process.The high alkalinity is attributed to the uncontrolled usage of lime through the precipitation processes.However, the considerable amounts of sulphate found are due to a slight dissociation of added alum(4). The total hardness is low due to the precipitation of the cations responsible for hardness in this area;this also results in a considerable drop in the total dissolved solids. Wastewater emanated from the 3rd area is characterized by its high sulphides content(82 - 980 mg / l) ,with a considerable thermal impact as a result of high temperature (30 - 65°C) of this wastewater.The high values of BOD can be related to the high sulphides levels (4).The presence of sulphates and total hardness can be attributed to the dissolution action of hot water used for mining processes.

Table(1)Characterstics of Mishrak's wastewater for different production areas.

Parameter	1st Area	3rd Area	4th Area	Disposal site
Temperature,°c	7-31	30-65	8-31	8-31
pH	8.5-11.5	7.5-8.5	1.3-1.9	2.1-3.3
Sulphate,mg/l	85-170	610-1310	600-6500	400-3500
Sulphide,mg/l	-----	82-980	0-10	0-6.5
BOD, mg/l	0.2-15	150-700	0-6	0-3.7
DO, mg/l	7.5-9.2	0.0-1.2	7.5-8.5	6.3-7.8
Total hardness mg/l	80-185	500-2050	900-1850	600-1300
Total dissolved solids,mg/l	30-300	1300-4500	4500-10000	850-2250
Suspended solids mg/l	600-9500	50-1150	600-2000	800-1400

Wastewater released from the 5th area is highly acidic with a pH value in the range (1.3 - 1.9).The high acidity can be related to the uncontrolled usage of sulphuric acid in the debitumenization units and the incomplete neutralization of remaining acid in the filtration contact tanks.This wastewater contains high values of suspended solids,due to the presence of small particles of foam evoluted from the purification processes.The presence of large quantities of dissolved organic solid can be related to the removal of associated organic matter from the raw sulphur at the debitumenization units. However,the considerable amounts of total hardness present in this wastewater result from using large quantities of lime,cellite and tonsil through the purification processes (4).The anaerobic action of sulphate-reducing bacteria on the wastewater converts low percentage of sulphates to sulphides(5,6).However,the temperature,DO and BOD are within the normal limits.
The solid-wastes leachate is characterized by high acidity ranging from pH=2.1 to 3.3 with considerable amounts of sulphate,total dissolved and suspended solids and total hardness.

IMPACTS OF POLLUTANTS SOURCES ON WATER-RESOURCES QUALITY

The wastewater emanated from sulphur complex is loading the river Tigris at Mishrak with many pollutants.From the data obtained by this study,it can be said that the variations in all concentrations of pollutants are characterized by considerable changes along the period from May to October,as the discharge of Tigris river is low during this period (8) .
A sharp rise in the concentrations of pollutants was quite obvious during the period from June to August.However,the maximum concentration of most pollutants was during August .The impact of the 1st area on Tigris-river water quality is shown in fig (3).It is clear that the wastewater has no significant

effect on the river water quality except a slight increase in the pH value and a considerable increase in the suspended solids due to the wastewater emanated from the water-purification process.In a short distance downstream from the point of the 1st area wastewater outfall the effect of the mentioned pollutants disappeared due to the high dilution factor with respect to the discharge of the river.Figure(4)reflects the effects of mining wastewater on Tigris river water quality.The concentration of sulphides ,at the point of wastewater outfall,is deviating from the standard limits of rivers (7).

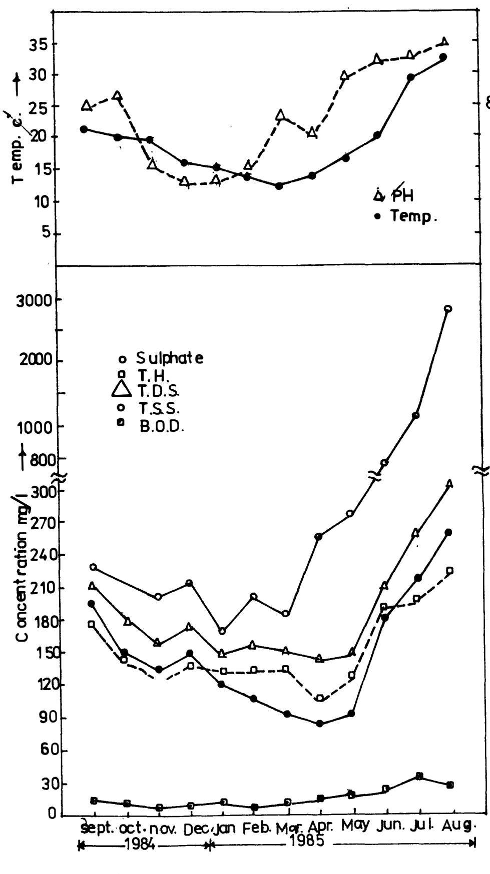
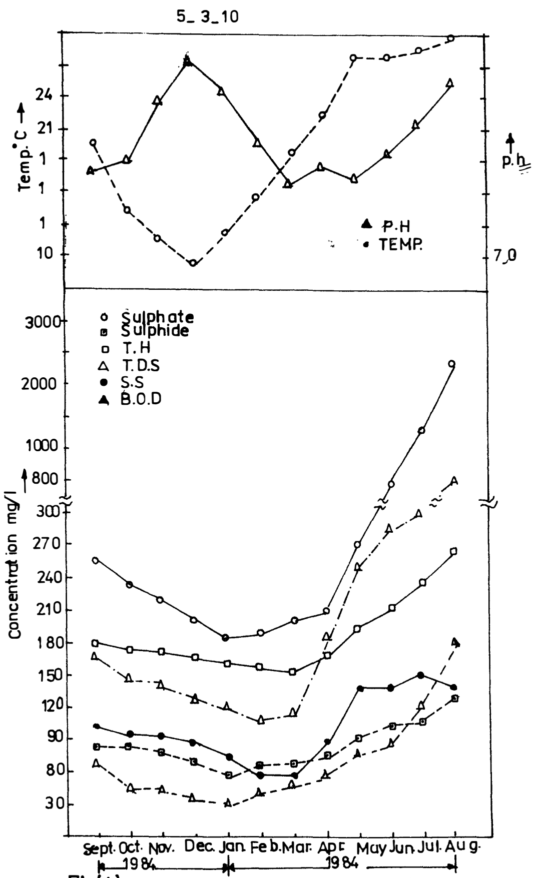


Fig (3)/Concentration of pollutants at station(1)



Fig(4)Concentration of Pollutants at Station (2)

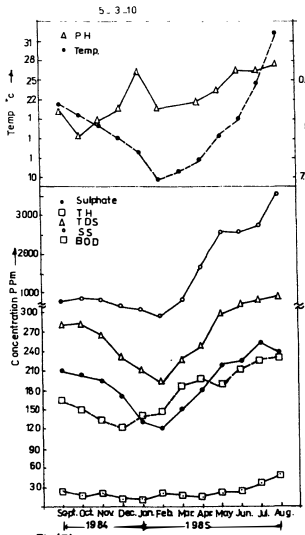


Fig.(5) Concentration of Pollutants at station (4)

Results from analysis of water quality show gradual decrease in pollutant concentrations at sampling points at (100,500,1500m)downstream of the wastewater outfall.These results show that the concentration of sulphides reaches a level that may be considered dangerous to humans,animals,plants and aquatic life(8). Al-Safeena villagers consume water for domestic purposes with sulphide concentrations ranging from 0.1 to 1.82 mg/1.This level is not compared with the river quality standards (7).The dissolved oxygen between the points 100m and 500m is low within so that it is insufficient to support aquatic life.The values of BOD,suspended solids,sulphates and total hardness are relatively high.From fig(5) it is obvious that the wastewater released from the purification area has a considerable effect on Tigris river water quality.The concentration of sulphates and total hardness are more than the permissible levels of drinking water (7),mainly at the period of water scantness of the river. Concentration of total dissolved and suspended solids are high,but the temperature and pH are within the normal levels.The concentrations of sulphates, total hardness,BOD,suspended and dissolved solids reduced gradually by self purification of the river during its travel downstream from Tal-Alshook village(8) Table (2)displays the water quality parameters of the wells at the villages: Al-Seffana,Hathra Al-Fathel,Tulool Nesir, Um-Al-Manasses and Tal-Alshook.

Table (2) / Water Quality of the Wells

Village	Sulphates. mg/l	Sulphides. mg/l	Total hardness. mg/l
Al-Sefeena	1722	0.01	1910
Hathrat Al-Fathel	1750	0.09	2723
Tulool Nasir	2421	0.05	2410
Um-Al-Manasses	2609	0.02	2305
Tal-Alshook	2955	0.05	3266

The presence of sulphides in these wells can be attributed to the seepage of sulphide-enriched water from mining area,purification of wastewater and leachate of solidwaste.However, these concentrationsare below the hazard limits.The high concentrations of sulphates and total hardnesscan be related to the impact of Mishrak's wastewater and the nature of lower tars formation layer which contains gypsum in the region through which the groundwater percolates (4).

CONCLUSIONS AND RECOMMENDATION

Mishrak sulphur enterprise adds high loads of pollutants to water resources at Mishrak, through the wastewater released from each production area.The magnitude of pollutants in Tigris river is a seasonal function. High concentrations of pollutants generally occur during the period May to October, due to the low flow rate of the river in this period. The wastewater discharged to the river contains high concentrations of pollutants exceeding the recommended discharge standards(7). Sulphides released from the 3rd area create oxygen depletion in Tigris river and the ecosystem is severely disrupted. Recovery from this pollution extends over 1800m downstream of the discharge point. Downstream of the disposal point of the 4th area, water contains sulphates and total hardness exceeding the desirable levels for drinking water (7). The distance extending from the 3rd area 1200m downstream to the discharge point of the 4th area suffers from severe pollution. The high dilution factor of Tigris river minmizes the effect of pollutants on its quality and recovers it at 1500m downstream of the Mishrak area.

The water quality of the wells shows a slight pollution with sulfides and high concentration of sulphates and total hardness. The expected expansion in the production in the future will exceed the environmental impact of Mishrak wastewater on the quality of water resources in this area. This impact will detriorate the water quality and perish the aquatic life.

To conserve the quality of Mishrak's water resources and to prevent the deterioration of the water quality, the following is recommended.

1. Careful consideration should be given to wastewater released from 1st area by preventing the disposal of sludge produced by the clarification process directly to the river. This sludge can be used for land filling in the mining area.
2. Equalization tanks are recommended for mining and purification wastewater to adjust their quality factors before treatment.
3. It is necessary to adopt water reuse mainly in the debitumenization units in order to cut down the wastewater disposal.
4. It is recommended to construct a wastewater treatment plant consisting of biological treatment for the removal of high quantities of sulphides evoluted from the mining area, and chemical treatment for the removal of chemical pollutants disposed by the purification area.
5. A proper lining of the disposal site of solidwastes provided with lime covers will reduce the acidity of leachate by neutralization and prevent the seepage of the leachate to the neighbouring groundwater.

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