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MINE WATER EFFLUENT QUALITY IN THE ILLAWARRA REGION

by

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ABSTRACT

The mining industry in the Illawarra region exists in one of the most environmentally sensitive areas. An assessment of various water quality parameters are presented for nine mine effluent discharges. Water pollution problems and receiving water quality impacts from various sources are identified. Further studies are required for more precise assessment and quantification.

INTRODUCTION

During the last decade the environment in general has become a prime concern to the society. The society has realised that changes in attitudes towards the environment are to be made if sustainable industrial, economic and social development are to be maintained. Such development applies to the mining industry and particularly to coal. The current dependence of man on coal has meant that the slogan 'Man must mine, he must dig or die' is appropriate for the coal industry. The problems and sustainability of ecological systems are of fundamental importance to ecologically sustainable mining.

One of the most important coal mining regions of Australia - the Southern Coalfield exists within the Illawarra region. The coal mined is a prime hard coking coal, mainly used in the coke ovens at the Port Kembla and Whyalla steelworks and exported to steelworks in Asia, Europe and South America. The Joint Coal Board (1) estimates that approximately 18 million tonnes of raw coal is produced annually from the Southern Coalfield.

Underground mining is being carried mostly at the Illawarra escarpment with strict environmental controls. Surface water quality information on the mine effluent receiving waters of the Illawarra region is lacking. This study was designed to assess mine effluent water quality in the Illawarra region and to understand the impact this water has on natural water courses. In addition to this, the study was designed to identify the source of the problem and to suggest ways to improve them.

STUDY AREA

THE ILLAWARRA REGION

The Illawarra region is divided into a coastal and an upland area, stretching along the coast from the Royal National Park in the north, to Durras Water in the south and extends 30km inland. The region incorporates 13 mines and their locations are as illustrated in Figure 1.

As can be seen from Figure 1 that coal mining is concentrated around the city of Wollongong. The city is heavily industrialised and located on a narrow coastal plain which rises to an escarpment to a plateau. A part of the plateau acts as a water supply catchment area for Wollongong and Sydney and has restricted access in many areas. Some mines operate up stream of this catchment area. Most river systems also originate in the plateau and flows eastward to the sea and some into Lake Illawarra and others through the National Parks. Most mines discharge to a nearest creek/river system. Surface water bodies in this region are already under stress due to various urban developments. Hence combined with mining activity the environmental sensitivity of this area do not need further emphasis.

GEOLOGY AND CLIMATE

The Illawarra coalfield lies in the south-eastern part of the Sydney Basin, where the strata consists mainly of sedimentary rocks of Triassic and Permian age. The strata overlying the Illawarra Coal Measures is a series of interbedded sandstones and shales of the Narrabeen Group. These in turn are overlain by a thick massive sandstone unit, the Hawkesbury Sandstone. The Hawkesbury Sandstone outcrops, covering most surface areas, is overlain in some parts by a thin veneer of Wianamatta shale. Talus slopes extend from the base of the Illawarra escarpment onto the coastal plain.

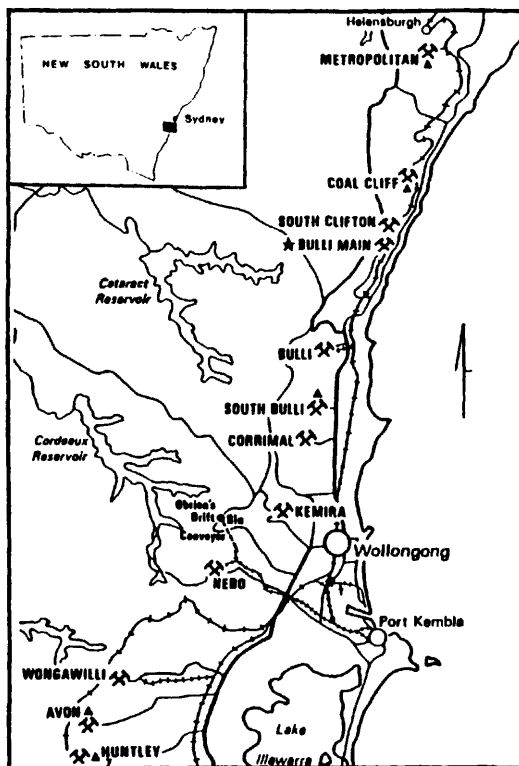


Figure 1 Coal Mines in the Illawarra Region.

The Illawarra Coal Measures extend over much of the escarpment. Since the strata is generally only slightly dipping, mostly at only a few degrees, the mines are able to directly follow a coal seam from its outcrop, usually near the top of the lower slopes of the escarpment.

Four significant coal seams have been mined but only two are currently worked - Bulli and Wongawilli Seams. The Tongarra Seam, which is not currently being mined, is the deepest seam. Up to 2.7m of its upper section has been mined in the past. About 30m above, is the Wongawilli Seam, of which about 2.7m of the bottom section of its 11m width is mined. Next is the Balgownie Seam, more irregularly distributed than the other coal seams and with thickness usually about 1.2m or more. The uppermost seam is the Bulli Seam which averages about 2m thickness in the northern part of the area where it is extensively mined.

Rainfall over the area is controlled largely by orographic uplift at the escarpment, and is relatively high. The medium annual rainfall is mostly between 1000 and 1250mm. In places, rainfall is up to 1500mm which is high by Australian annual standards. The wettest months are usually December to April. Maximum monthly temperature generally ranges from about 14°C in July to about 26°C in January. Annual evaporation averages about 900mm.

COAL CONSTITUENTS

Coal is a combustible solid composed of organic compounds derived mainly from plant matter and inorganic constituents. The inorganic constituents may be grouped as:

- a. silica and the silicates, the clay minerals being dominant;
- b. carbonates occurring in combination with iron, calcium and magnesium;
- c. sulphides occurring in minerals with iron (mainly pyrite), zinc, lead, copper and nickel;
- d. sulphates of calcium, barium and hydrated iron;
- e. miscellaneous constituents in low concentrations.

Australian coals tend to be low in most trace elements, partly because of the low content of pyrite and other sulphide minerals and also because extensive mineralisation does not occur near the coal seams. Toxic elements such as arsenic, beryllium, cadmium, mercury and selenium are low in comparison with coals from the eastern United States coal regions.

During the extraction of coal from the seam, changes such as oxidation may release trace metals to ground and surface waters.

WATER QUALITY PARAMETERS

Mining operations invariably give rise to effluents which may contain potential pollutants. A general overview of potential contaminants and their effects on water quality emanating from mining operations is outlined by Sivakumar (2). However the surface water pollution encountered by underground mining operations can be broadly categorised into physical, chemical (organic and inorganic), bacteriological and radiological parameters. In the case of the Illawarra region the primary water quality parameters are of physico-chemical nature.

The selected parameters and their method of determination are as shown in Table I. The analysis were carried out at the Environmental Engineering and Chemistry laboratories of the University of Wollongong in accordance with the Standard Methods (3).

The measurement of volumetric flow rate is of crucial importance for the interpretation of results as well as for the design of remedial measures. Hence flow rate information is measured at each site.

FIELD SAMPLING PROGRAM

The field sampling program is designed to comply with the two primary aims: one to study the mine effluent water quality and secondly to assess the impact this mine effluent water has on local waterways. Hence wherever possible three principal sampling locations are chosen for each mine.

TABLE I
METHODS FOR WATER QUALITY DETERMINANTS

Parameter	Method of Analysis
Temperature	Mercury Thermometer
pH	pH electrode meter
Electrical Conductivity	Conductivity meter
Turbidity	Turbidity meter
Total Alkalinity	Titration
NFR	Filtration
Apparent Colour	Spectrophotometer
BOD	Dissolved oxygen meter
COD	Spectrophotometer
TDS	Calculation
SO ₄ ²⁻	Gravimetric
Fe, Mn, Al	AAS
K, Na, Ca, Mg	AAS
Total Hardness	Calculation
TSS	Calculation

The first sample location S1 is situated upstream of any mining influence the stream may encounter and in some cases S1 samples become the make-up water used for that mine.

The mine discharge becomes the second sampling location S2.

Finally the third sampling location S3 is downstream from the discharge and any mining activity.

At each sampling location approximately 4.5 litres of sample are taken. 2x2 litre polyethylene containers and 1x0.5 litre polyethylene container are used. One of the 2 litre containers is kept free of any preservatives. Whereas the second is acidified to a pH < 2 with concentrated nitric acid (HNO₃). The 0.5L polyethylene container is also acidified to a pH < 2 but with concentrated sulfuric acid (H₂SO₄). Acidification is tested by universal indicator paper. Each sample is labelled immediately after treatment and placed into an ice packed refrigerator. On return to the laboratory all samples are placed into a refrigerator. Measurements taken in the field are flowrate and water temperature. The water quality parameters measured as well as the special handling requirements of the samples are summarised in Table II.

RESULTS AND DISCUSSION

The field sampling results of all the mines are summarised here without naming the mine for purposes of confidentiality. Hence the mines are identified as A,B,C,D,E,F,G,H and I.

TABLE II
SUMMARY OF SAMPLING REQUIREMENTS

Container	Preservative	Parameter	Measured Time
2.0 litre		pH	< 24 h
		conductivity	< 48 h
		NFR	asap
		App. Colour	< 48 h
		Turbidity	< 48 h
		BOD	< 24 h
		Alkalinity	< 24 h
		Sulphate Chloride	< 14 days < 14 days
2.0 litre	Add HNO ₃ to pH < 2 Refrigerate	Fe	< 1 month
		Mn	< 1 month
		K	< 1 month
		Al	< 1 month
		Ca	< 1 month
		Mg	< 1 month
		Na	< 1 month
0.5 litre	Add concentrated H ₂ SO ₄ to pH < 2 Refrigerate	COD	< 14 days

WATER MANAGEMENT PRACTICES

Any water quality assessment program should identify the current water management practices of the mines. It has been found that this indeed vary quite significantly from one mine to the other. Some mines rely on town water, others from dam and other mine drainage waters while others use recycled water both from process water as well as from the stormwater runoff.

The type of mining processes such as washeries, dust suppression etc. produces effluent which need to be treated before disposal. The stormwater quality and quantity also need to be managed at the site.

DISCHARGE STANDARDS

Under current legislation mine discharged water is grouped as being either site releases or discharges (McCotter, 4). The latter are defined as the loss of water from a site by deliberate human or mechanical intervention such as pumping or the opening of valves. Licences for discharges vary from colliery to colliery depending on the classification of their local waters but generally speaking the discharge limit are as follows:

1. Chemical Oxygen Demand (COD) ≤ 30 mg/L
2. Non-Filterable Residue (NFR)
 - non sensitive area ≤ 50 mg/L
 - sensitive area ≤ 30 mg/L
- 3 pH = 6.5 - 8.5

Pit waters are normally controlled by pumping and limits are frequently placed on their direct discharge into receiving waters. Where possible, collieries are encouraged to recycle pit water for dust suppression, washery make up, and other on-site uses.

Site releases refer to the loss of water from a site by the overflowing of dams and other control structures during storm events. As they are caused by natural weather conditions, it is not deemed feasible to license the actual water release. Instead, satisfactory water quality is achieved through the placing of performance specifications on the necessary control works. This is achieved by the procedure outlined in the Clean Waters Act. Runoff from haul roads and unrehabilitated overburdened areas is governed by these provisions.

WATER QUALITY PARAMETERS

The various water quality parameters of each mine was investigated at three locations. It is found that most mining effluent discharges have a noticeable impact on the receiving water body. Detailed discussion on the individual mines water quality is reported by Morton (5).

Table III summarises the water quality parameters of the mine effluents which is an average of three separate field trips. Despite the fact that the frequency and duration of the sampling is short the trends are clear. Since the sampling was essentially carried out during dry weather flows the values will be only representative for dry flow conditions.

The conductivity, TDS and TSS of all mine effluent waters were found to be higher than the raw water sources indicating the accumulation of soluble ions which give rise to salinity. Most mine waters were found to be moderate to very saline which are similar to other industrial discharges.

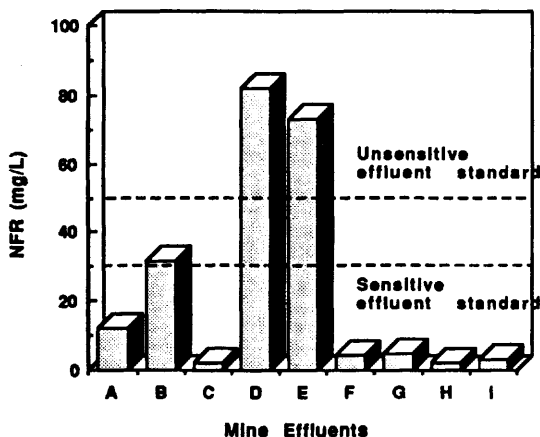


Figure 2 NFR of Mine Effluents in the Illawarra Region

The alkalinity of the effluents were found to be high whereas acidity was not a problem. For example Mine G has the highest alkalinity, sulphate and sodium levels. The effluent water from this mine is of sodium carbonate type and is characteristics of contamination from waters from deep sedimentary rocks.

The iron levels of the effluents seem variable. However the iron content of the Mine G effluent is too high which will give rise to discolouration of the receiving water and may destroy the food chain to other aquatic organisms.

The Mines A,D and E have particular problems with NFR, COD, pH, colour, turbidity and aluminium levels.

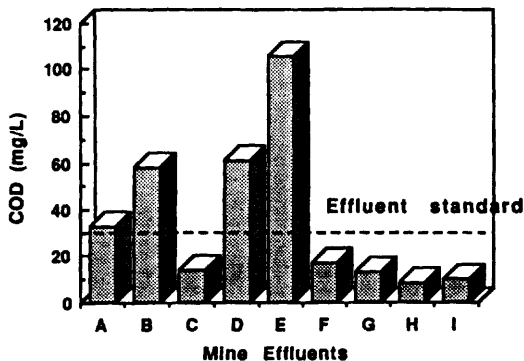


Figure 3 COD of Mine Effluents in the Illawarra Region

The level of NFR, COD and pH of all the mine effluents are shown in Figures 2,3 and 4 respectively. Although the Mines B, D and E effluent quality seem to exceed their discharge standards the results should be interpreted with caution. These results are based on limited data and detailed studies on the variability of these parameters on weather conditions, mine operating practices etc. are necessary for further interpretation.

It was found that the effluent standards of the Illawarra mines for pH, COD, NFR(sensitive) and NFR(Insensitive) have exceeded by 33%, 44%, 33% and 22% respectively as shown in Figure 5. During extended wet weather flows these values may be expected to be lower due to dilution effects.

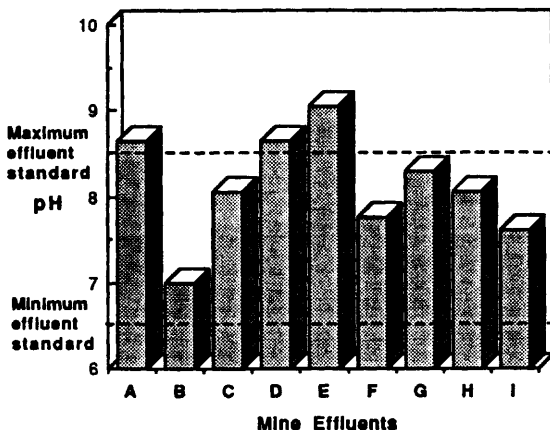


Figure 4 pH of Mine Effluents in the Illawarra Region

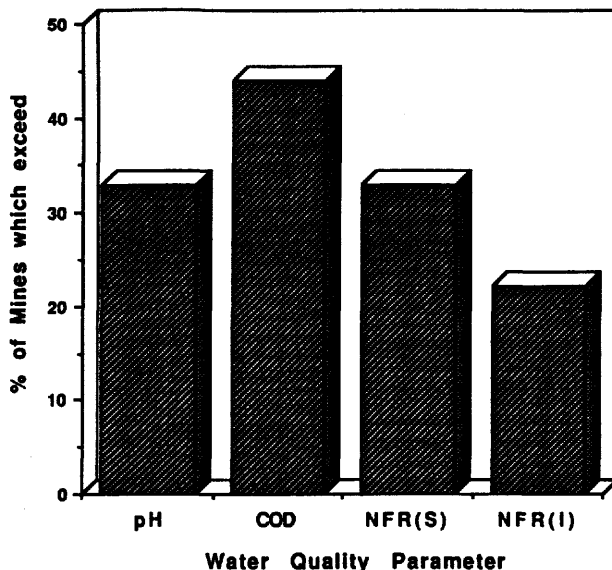


Figure 5 Overall Assessment of Mine Effluent Quality in the Illawarra Region

IMPACT ON FUTURE WATER QUALITY GUIDELINES

It appears that the current discharge standard parameters for mine effluents is not adequate. Future guidelines should incorporate discharge standards for oil and grease, salinity or TDS, some specific heavy metals for mine effluents as well as quality control of stormwaters emanating from the mining areas.

The recent draft discussion paper by the SPCC (6) appear to be a comprehensive document and if applied to Illawarra mine effluents, the majority of the mines have to take corrective action before discharges or site releases.

EFFLUENT MANAGEMENT PRACTICES

REDUCE, REUSE AND RECYCLE

As the surroundings to the mining operations in the Illawarra region consists of very sensitive environments it is of paramount importance to manage the effluents before being discharged. The simple concepts such as Reduce, Reuse and Recycle should be adhered and practiced. For example it can be seen Table III that Mine F effluent quality is very good and this mine in fact not only uses the above concepts but their effluent also undergoes filtration before reuse.

ONSITE TREATMENT

The good effluent management system for the region should consist of a properly designed system of ponds for storage of effluents with removal mechanisms for oil and grease, chemical dosing for removal of fines and perhaps some type of efficient filtration depending on the particle sizes. Thereafter the treated water can be reused for a variety of applications. The industry should also move towards a near zero discharge option.

COMPUTER CONTROL DISCHARGES

The readily measurable water quality parameters of the mine effluent are NFR, TDS or pH. These parameters can be monitored at the discharges or site releases as well as downstream of the discharge locations in real time using simple indirect methods using probes. When the monitoring equipment is connected to a personal computer various types of useful information can be obtained. For example this system may be used as an early warning for accidental releases or other malfunctions. Also the information obtained can be used to control the site releases or discharges based on the receiving water quality such as storing and releasing when the dilution effect is will be high.

CONCLUSIONS

Mine effluent water quality of the Illawarra region varies significantly from close to natural water to water similar in standard to industrial effluent. The primary pollutant is the salinity. It was found that 48% of mines exceeded the limit for COD (sensitive), 36% of mines exceeded the limit for pH and 20% exceeded the limit for NFR.

Some mine effluent waters had high alkalinity levels. This became common for waters derived from particular types of sandstone.

It was found that the mining operations in the Illawarra region may contribute to the pollutant loadings of near-by receiving water bodies. This was particularly obvious at Mines A, D and G where such pollutants as NFR, pH, COD, apparent colour, turbidity, iron and aluminium concentrations were found to be high during this limited study.

However with the implementation of the new and forthcoming water quality regulations, these mines will need to improve their mine effluent management practises. To achieve this, considerable economic pressures will be placed on all mining companies.

The limitations in this study include lack of data on seasonal variation as well as information on water quality parameters such as heavy metals, Boron, oil and grease as well as chloride levels. Future studies should focus on these issues.

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