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Abstract

Pollution is usually perceived to be man-made, but in fact the atmosphere and waters of the earth can also be contaminated as a result of natural events. Volcanoes can emit huge clouds of gases and ash, and flooded rivers typically carry high loads of silt and organic debris. Nor is such naturally-occurring pollution always associated with extreme events (which happen rarely but cause major impacts) such as volcanic eruptions. For example, soils developed where gossan (the oxidized crust on an ore body) outcrops at the ground surface may contain very high levels of the metals found in the are itself - levels that would be labelled highly contaminated if they occurred in waste deposits from a mining operation. Nevertheless, it is obvious that urbanisation and industrialisation increasingly produce a range and quantity of contaminants which the natural environment cannot absorb without being degraded and which can have deleterious effects on human beings. Because the problem has seemed to be so serious, most countries have legislation and controlling authorities designed to minimise pollution and its impacts.

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PROBLEMS IN THE URBAN ENVIRONMENT: POLLUTION IN THE WOLLONGONG–SHELLHARBOUR AREA

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Pollution is usually perceived to be man-made, but in fact the atmosphere and waters of the earth can also be contaminated as a result of natural events. Volcanoes can emit huge clouds of gases and ash, and flooded rivers typically carry high loads of silt and organic debris. Nor is such naturally-occurring pollution always associated with extreme events (which happen rarely but cause major impacts) such as volcanic eruptions. For example, soils developed where gossan (the oxidized crust on an ore body) outcrops at the ground surface may contain very high levels of the metals found in the ore itself - levels that would be labelled highly contaminated if they occurred in waste deposits from a mining operation. Nevertheless, it is obvious that urbanisation and industrialisation increasingly produce a range and quantity of contaminants which the natural environment cannot absorb without being degraded and which can have deleterious effects on human beings. Because the problem has seemed to be so serious, most countries have legislation and controlling authorities designed to minimise pollution and its impacts.

Pollution is often thought to be a problem only in areas close to sources of pollutants, but it is important to note that it can be transmitted from region to region. An example of this is acid rain. Oxides of sulphur and nitrogen produced in major industrial aeas (such as in Germany and England) by the burning of fossil fuels are transported by the atmospheric circulation across other countries (notably in Scandinavia). There, they are absorbed by falling rain, so that the rainfall becomes very acidic, causing great ecological damage to small lakes (Likens et al, 1979). In Australia, there can be political conflicts across state borders, with the increasing salinity of the Murray River as it passes through irrigation areas being a notable example (Davis, 1978). And even at the local level, there can be inter-regional conflicts. High levels of ozone (a component of photochemical smog which is used to indicate smog severity) recorded at Austinmer and Robertson are partly derived from polluted air from Sydney circulating across the Illawarra region. Therefore, while this report deals mainly with local examples, it must be remembered that pollution in any one area is partly a function of that produced in adjacent areas.

AIR POLLUTION

1) Sources of pollutants: The most obvious source of pollutants in the region is the industrial complex in the Port Kembla area (Figure 1). Within this complex, several major activities are carried out:

(a) Steelmaking by Australian Iron and Steel (AI&S). This activity uses iron ore (mainly from Mt. Newman in Western Australia) and coke made on-site from locally-produced coal. The major emissions are of particulate matter containing iron, manganese and nickel (mainly as oxides), plus steam and acid gases from the coke ovens area.

(b) Plating of steel at the adjacent John Lysaght works.

(c) Smelting of non-ferrous metals at the works of the Electrolytic Refining and Smelting (ER&S) Company. The smelting process uses heavy metal sulphide ores from the Mt. Lyell mine at Cobar and the Woodlawn mine near Lake George (NSW). The major emissions are heavy metals (especially copper, lead and zinc) as sulphides, sulphates and oxides, plus acid gases.

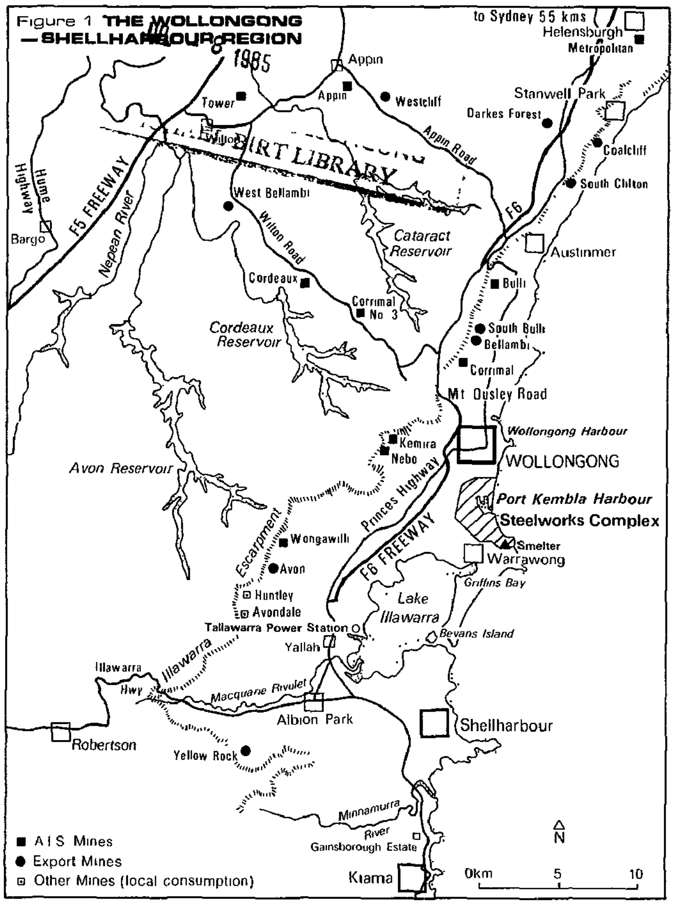


Figure 1 THE WOLLONGONG —SHELLHARBOUR REGION

(d) Loading of locally produced coal, for export by ship, mainly to Japan. This can create windblown dust.

Given the very large source area covered by these activities at Port Kembla, it is easy to overlook the more dispersed and more familiar sources such as motor vehicles and backyard incinerators. Yet research into Sydney's air pollution problems shows that these are major sources of pollutants (Bell, 1981-82).

2) The distribution of air pollutants: In summer, northeasterly sea breezes move pollutants from the Port Kembla area across Lake Illawarra towards Albion Park and nearby suburbs. This is evident from analyses of sediments and organisms in Lake Illawarra (Young, 1976) which showed that sediments in the northern part of the lake contained flyash particles, and high concentrations of heavy metals in the topmost 20cm. Worms and molluscs collected from Griffins Bay contained higher concentrations of heavy metal than those collected from Bevans Island, six kilometres south-south-west of the ER&S smelter (none of the levels was, however, exceptionally high by National Health and Medical Research Council standards). As the north-easterly breezes are rarely strong enough to force the main body of air up and over the escarpment, pollution is often trapped in the valley of the Macquarie Rivulet. Conditons there can become progressively more hazy until a southerly change clears the air. The north-easterlies can also bring into the Illawarra polluted air which has previously moved offshore from Sydney.

During winter, strong and persistent south-westerly to north-westerly winds blow pollutants well offshore and can provide very clean air over the city. When these winds are not blowing, however, rapid cooling at ground level during the night can produce an atmospheric temperature inversion. Pollutants are trapped near the ground below the warmer upper air and a dense haze settles over the city. As these inversions break up during the day, and also during unstable weather conditions, a single cumulus cloud sometimes forms near the industrial complex. This is presumably due to the combination of additional heat (producing rising air), water vapour and particulate matter (providing cloud condensation nuclei) emitted from this area.

The densest network of air pollution monitors in the Illawarra is that used in a short study by Archbold and Crisp (1982). Sixty-three small bags of **Sphagnum** (peat) moss, a very efficient collector of atmospheric dust, were exposed for about three months at a time. The dust was then rinsed out and analysed, to give comparative levels of air pollution by metals throughout the area for the period of measurement (Figures 2 and 3). Note that the isolines on these figures show only relative levels, the highest isoline value representing the maximum concentration measured for the period up to the collection date. On Figure 2 a value of 1 represents 1/8 of the maximum concentration recorded for samples collected in September 1980 and April 1981; but the maximum concentration for September 1980 was only about half that for April 1981 (because of varying emission rates and meteorological conditions). Hence we can compare the **patterns** on the different diagrams, but not directly the isoline values.

For iron, the greatest concentration is of course around the steelworks. Concentrations drop rapidly, to less than a quarter of their maximum value within three kilometres. Most of the pollutants emitted must drop to ground rapidly. There are small peaks in the recorded iron levels, both along major industrial road haulage routes (such as Mt. Ousley Road) and near steel fabricating works about five kilometres southwest of Port Kembla. Lead levels show an even more marked concentration around their source area (in this case, the ER&S smelter) and again a small peak near Mt. Ousley Road. This small peak confirms that road dust and vehicle emissions are a significant source of air pollutants in the region.

3) A comparision of air pollution levels in Sydney and Wollongong: The State Pollution Control Commission (SPCC) maintains a sparse network of monitoring stations throughout the state, the sites and the pollutants analysed being designed to provide information about specific problems rather than a comprehensive survey. It should be remembered that the value for any pollutant can vary widely with the type of measuring equipment used, the period of sample collection (shorter times yielding higher and more fluctuating values) and the standard of air temperature and pressure in which the value is reported. Table 1 shows a selection of lead levels (in microgrammes per cubic metre at 0°C, based on 24-hourly samples) recorded for Warrawong, Port Kembla and the central business district of Sydney.

TABLE 1: LEAD LEVELS (ug/m^3, 24 HOURS) IN WOLLONGONG AND SYDNEY

		1976	1978	1980
Warrawong	av.	0.4	0.3	0.5
	max.	2.5	1.2	1.4
Port Kembla	av.	1.5	2.7	7.8
	max.	7.8	13.6	29.1
Sydney CBD	av.	2.6	2.7	2.4
	max.	8.9	6.5	4.5

Source: SPCC, Quarterly Air Pollution Reports

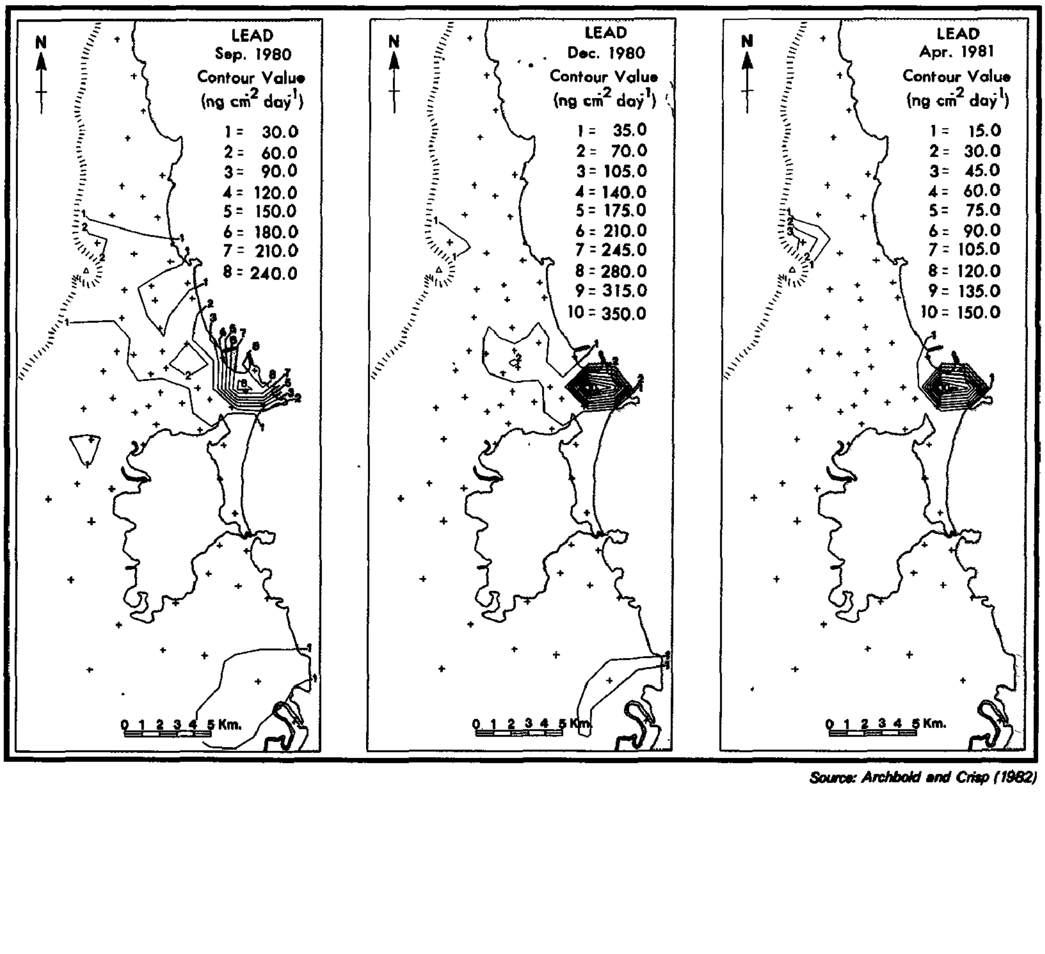
Close to the smelter, at Port Kembla, maximum recorded levels are consistently very high. Indeed in 1979 they reached 52.0 ug/m^3! However, both maximum and average concentrations are far lower at Warrawong, only two kilometres to the southwest. This confirms the more detailed but shorter term pattern shown in Figure 2. Prior to 1979, average levels at Port Kembla were not markedly different from those in the CBD of Sydney, where lead is derived mainly from vehicle emissions. Given the rapid fall in lead levels away from the smelter, it is clear that in most of the Wollongong-Shellharbour area, lead pollution is less severe than in those parts of Sydney that are subjected to prolonged heavy traffic. Comparison of data for acid gases (Table 2) and also for suspended particulate matter (ie dust) show a similar pattern to that for lead. The major industrial contributors to acid gas emissions are the smelter, the steelworks and Tallawarra Power Station. Of these, approximately 73% of emissions come from the ER&S smelters, 21% from the AI&S complex and 6% from the power station. These ratios may vary slightly with changing production rates. Note too that no estimate has been made for the contribution to acid gas levels from motor vehicle emissions. Concentrations of acid gases are much lower in Warrawong than in central Sydney (unfortunately, no data are available for the Port Kembla area). Obviously pollutant levels in many Sydney suburbs will also be lower than those experienced in the CBD. But the fact remains that Wollongong's air is often cleaner than much of Sydney's. However the air pollution problem caused by the major sources in the Illawarra is perceived as serious and thus affects local property values (Dalziel and Gallagher, 1977).

WATER POLLUTION

1) Sources of pollutants: As in the case of air pollutants, the industrial complex at Port Kembla is a large and obvious source of water pollutants. Virtually all the discharges of polluted water from the complex are directed into the Port Kembla harbour. Again, as in the case of air pollutants, however, we should not overlook the more dispersed sources. These include:

(a) Polluted runoff during

Figure 2: **DISTRIBUTION OF LEAD FALLOUT**



Source: Archbold and Crisp (1982)

storm conditions from some collieries. In this context, it is important to note that the coals mined in the region are low in sulphur (often less than 0.5%) and do not produce the acidic and iron-contaminated waste-water which causes severe pollution problems both elsewhere in Australia and overseas.

(b) Urban stormwater runoff which is usually contaminated by faecal bacteria (from animal droppings and from septic and sewerage overflows), by silt (from erosion of cleared land), oils and greases (from roads, driveways and garages), organic debris and litter.

(c) Direct discharge from sewerage treatment works across beaches or from near-shore outlets. Such discharge occasionally causes severe fouling of the surf near the outlets.

2) The case of Lake Illawarra: Lake Illawarra is contaminated by two major pollutants - septic/ sewerage overflows and silt - both of which are due mainly to the urbanisation of its catchment area. Septic/sewerage overflows are important not only because they supply bacteria which, in high concentrations, are a health risk, but also because they supply nutrients (such as nitrogen and phosphorus) which induce rapid and extensive growth of algae (an algal bloom). The growth of the algae and their subsequent death and decay can drain the oxygen supply of the lake waters (as measured by the biochemical oxygen demand or BOD). This process in turn can lead to increased levels of hydrogen sulphide ('rotten egg gas', H_2S) which is smelly and also toxic to some lake organisms (Harris, 1976). As sewerage overflow vents operate only during major storms, the principal source of effluent has been from septic tank overflows. With sewerage being gradually introduced to urban areas around the lake, levels of faecal and nutrient contamination have progressively dropped over time.

Silt is the other major contaminant entering from the urban area. Obviously some sediment reaches the inflowing streams from erosion of the rural areas in the catchment (and, in the case of Macquarie Rivulet, this extends over the escarpment into the potato-growing area near Robertson) and from bank collapse. Much of it, however, comes from erosion of land left bare and unprotected during subdivision (Quilty, 1977). Clear evidence of this comes from records of the growth of Macquarie Rivulet delta, detailed in an earlier paper in this series (Young, 1982).

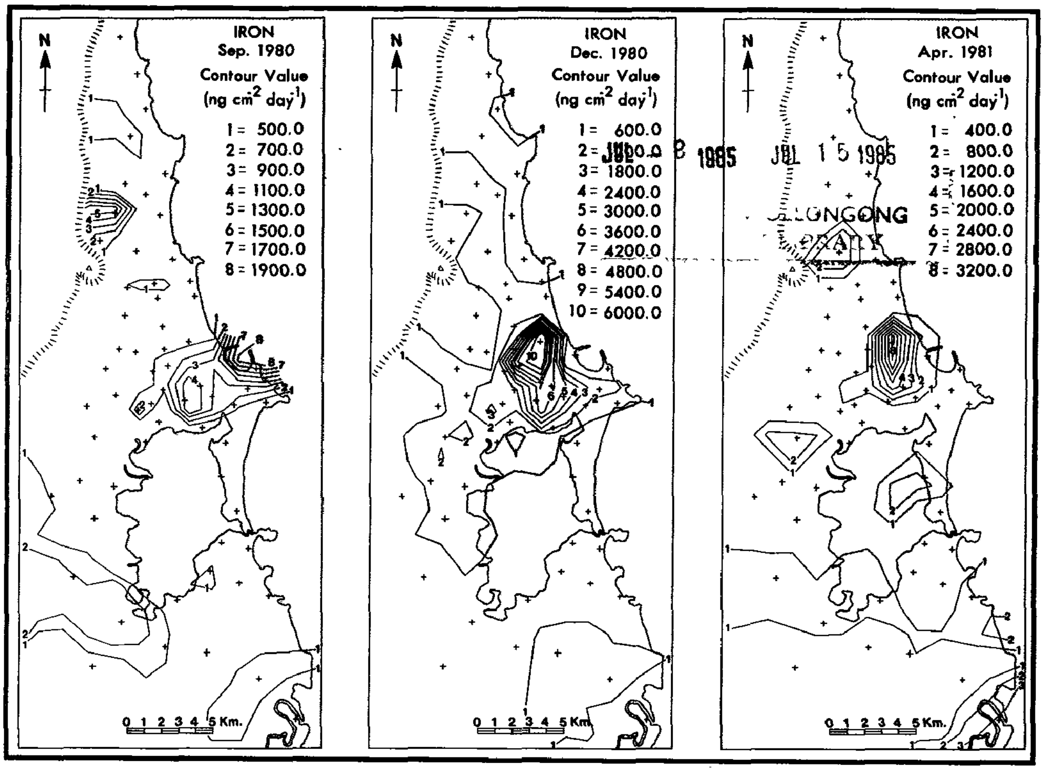
3) The case of Port Kembla harbour: In the mid 1970s, polluted discharges to the harbour created a warm plume about two metres deep flowing out to sea. The plume was severely oxygen-depleted and contained high concentrations of heavy metals, cyanide, ammonia, phenols and oils. It barely mixed with the colder, saltier (and thus denser) lower waters and was substantially diluted only when it reached the sea (State Pollution Control Commission, 1977). Partly as the result of community concern over fish kills (apparently caused

TABLE 2: ACID GASES (AS SO_2, ug/m^3 at 0^{o}C, 24 HOURS) IN WOLLONGONG AND SYDNEY

		1976	1978	1980
Warrawong	av.	11	10	10
	max.	94	70	70
Sydney CBD	av.	70	50	60
	max.	152	245	255

Source: SPCC, Quarterly Air Pollution Reports

Figure 3: **DISTRIBUTION OF IRON FALLOUT**



Source: Archbold and Crisp (1982)

when polluted water was mixed with deeper waters during ship movements), moves have been made to control the discharges to the harbour. Unfortunately the results of a recent survey of the harbour's water quality are not yet available, but several of the major discharges noted in 1977 have ceased. For example, cyanide and ammonia were, until recently, dissolved in the water which used to cool hot coke oven gases. This cooling is now done largely using heat exchangers, so the water and gases do not come directly into contact, and the cooling water discharged to the harbour is less polluted than previously.

The harbour is still badly polluted, despite these changes, as a comparison of the marine organisms there with those at nearby Wollongong Harbour (Moran, 1982) shows. Whereas Wollongong Harbour has many subtidal and intertidal species of marine organisms, the diversity of these animals in Port Kembla harbour decreases rapidly inside the harbour. Indeed the intertidal zone near the drains carrying the major discharges is completely bare. Moran's study concentrated on one group of organisms - the sessile invertebrates which attach themselves to boat hulls and piers.

There were fewer species of thse organisms in Port Kembla (40 species) than in Wollongong Harbour (53), and fewer in the Inner Harbour at Port Kembla (30 species) than in the Outer Harbour (35). Thus, the more polluted the water, the fewer the species. The **types** of organisms also differed. Bryozoans (sea mosses), serpulid polychaetes (tubeworms) and sponges were more numerous at Wollongong Harbour whereas ascidian chordates (sea squirts) and hydroids were important at Port Kembla (for descriptions of these, see Dakin (1976)).

Pollution does not apparently have acute toxic effects but influences the organisms indirectly and subtly. For example, because large algae grow poorly in the turbid water at Port Kembla, the initial development of invertebrates on a clean surface is often rapid; at Wollongong Harbour, where the water is clear, invertebrates and algae compete for space. Thus, initially, at Port Kembla the invertebrates are favoured. However, fewer species survived at Port Kembla than at Wollongong as the community developed. Pollution acted therefore as an artificial disturbance, altering the community's structure in comparison with that found in much less polluted waters.

STATUTORY CONTROL OF POLLUTION

The control and monitoring of pollution in New South Wales is the direct responsibility of the State Pollution Control Commision. This Commission, which was established under its own Act of Parliament in 1970, administers three control Acts - the Clean Air Act (1961) (formerly administered by the Health Commission), the Clean Waters Act (1970) and the Noise Control Act (1975). The Commission's early role in assessing the environmental impact of proposed developments largely passed to the Department of Environment and Planning after the Environment Planning and Assessment Act was passed in 1979.

The control Acts authorise the SPCC to require companies to install pollution control equipment and pollution monitoring systems, and to modify their operations so that discharges of pollutants do not exceed particular levels. Common methods of pollution control include the following:

1) For air pollution

(a) Catalytic reactors or afterburners, where waste gases are oxidized to a more acceptable (eg less smelly) emission. These are often expensive and nowadays are usually replaced by scrubber systems.

(b) Baghouses, where polluted air is passed up through bags of filter fabric to remove suspended particles. These are used at the Tallawarra Power Station, at the ER&S smelter and in parts of the steelworks.

(c) Scrubbers, where water sprayed in jets through a stream of polluted air dissolves or absorbs pollutants. Sometimes chemicals (including acids, alkalis and chlorinated water) are used to scrub the gases. Scrubber systems are employed at the Yallah rendering works and in several parts of the steelworks.

(d) Electrostatic precipitators, where oppositely charged plates and wires cause ionisation - and thence collection on the plates - of suspended pollutants. This method is used at the sinter plant at AI&S.

2) For water pollution

(a) Chlorination to reduce harmful bacteria, as used in water supply and sewerage treatment works.

(b) Retention and settling. Many solids will settle in ponds, particularly if they are artificially flocculated (ie coagulated into larger particles), allowing a clearer discharge to be filtered off through a permeable dam wall. Coal washeries employ this method. Where the water is contaminated by organic material, bacterial breakdown also occurs, but the dam wall is usually impermeable and the clear top water is decanted off. Such a system is used by abattoirs.

(c) Spray irrigation of partly treated water, which is used in connection with small ('package') sewerage treatment works (eg at collieries and at the Gainsborough estate in Kiama) to prevent large quantities of nutrients such as phosphates and nitrates from reaching the waterways. Spray irrigation is also used at some collieries to dispose of water contaminated by fine coal particles.

(d) Diversion to alternative uses. For example, some polluted water is used at the AI&S works to quench coke, and some of Lysaght's iron-contaminated waste acid is sold as a coalgulent to sewerage treatment works.

3) For noise pollution

(a) Sealing of windows and installation of air conditioners, as in clubs and hotels where rock bands play regularly.

(b) Enclosing of noisy areas within factories, to contain noise.

(c) Use of silencers on motors, particularly on air compressors used on the streets with jackhammers or pumps.

(d) Sophisticated computer models designed to estimate noise levels in residential areas. Australian Iron and Steel uses such models, since the number of sources of noise in the works is so large that piecemeal control is not effective.

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