Acid rain by robert angus smith essay

Science

The French chemist Ducros first used the term 'pluie acide' in 1845. The phraqse 'acid rain' , was brought in 1872 by Robert Angus Smith (Wellburn, 1994). Back in fifties, there were observations of lakes in Scandinavia losing their fish populations. Anglers and naturalists noticed that fish stocks in many lakes of southern Scandinavia were diminishing. Freshwater acidification had rapidly worsened over a few decades. Although acid rain and the acidification are a not new problem that has received considerable attention for many years, it was not until 1960s that scientists were able to link these effects to any specific cause. Later it was found to be atmosphericpollution. Acidification is not a regional phenomenon.

In Scotland, studies show that the acidification began around the middle of the last centuries and the process has accelerated in the last three decades. In southern Norway, It has reported that 87 lakes had a pH below 5. 5 (Mason, 1996). Damaged forests were becoming widespread in West Germany. As these examples show, acidification is an international problem. Pollutants may be carried with winds over distances, from points hundreds or thousands of miles away. Some countries are net importers of pollution, and others are exporters. The effects of acidification are varies, not only pollution of lakes and forests as previously mentioned, but also effects on fauna and flora, soil, groundwater and direct or indirect harm on humanhealth, and all things are influenced by water quality through hydrological pathway (Thunberg, 1993). The aim of this report is to discuss causes and effects of acidification that has been concerned until now, and present possible short-term and long-term solution to acid deposition effects on water quality

1. Acidification and its causes

Airborne pollution can influence theenvironmentboth directly and indirectly. Primary pollutant is Sulphur dioxide and nitrogen oxides. When these are present in high concentrations, they can cause damage on environment and human's health. These direct effects are often peak in the vicinity of the emission sources. Industrial society discharges suphur dioxide and nitrogen that form sulphuric acid and nitric acid, which may be carried with the winds over long distances before descending in rain orsnow. Indirect effects often occur as acidified soil and water far away from the sources of emission (Thunberg, 1993).

There are gas-phase reactions, which produce acidity in the atomosphere. Sulphur dioxide and nitrogen oxides form suophuric and nitric acids on coming into contact with water. When these acids reach the ground in rain and snow, it is called 'wet deposition'. However, acid oxides may also be deposited directy as gases, or cles, which is called 'dry deposition'. The rates of dry deposition velocity may depend on the nature of the land surfaces. Rates of wet deposition depend on the precipitation rate, the washout ratio of dissolved pollutant per unit mass of cloud water or rain divided by the concentration of the same pollutant per unit mass of air (Wellburn, 1994. A low pH value means a high level of acidification. Water in neutral condition has a pH of 7 (Thunberg, 1993). Sulphur and Nitrogen Cycles are presented below (Figure 1 and 2).

Figure 1. Sulphur Cycle Source: ICU (2003)

Figure 2. Nitrogen Cycle Source: ICU (2003)

1. 1 Sulphur

Sulphur compounds are responsible for about two-thirds of the acidification of rain. Sulphur in gaseous form, sulphur dioxide (SO2), is mainly formed in the combustion of oil and coal. The rapid increase in emission of pollutants came after the war followed by consumption of fuel and oil. It was reported that approximately 20 million tons of sulphur are now emitted every year in Europe. There is also a great deal of airborne pollution in North America, where about 12 million tons of sulphur is released every year. Sulphur can be formed by naturally by eruption of vulcanoes, from seas and oceans and certain processes in the soil. However, 90 per cent of the emissions of sulphur to the atmosphere are derived from industrialised parts of Europe and North America. This is ten times the level that can be considered natural (Thunberg, 1993).

1. 2 Nitrogen

Nitrogen oxides (NOX) are grouped term of nitrogen monoxide (NO) and nitrogen dioxide (NO2). Nitrogen oxides are formed in all types of combustion, most of the NOX are formed by the reaction of nitrogen gas in the combustion air with oxygen. When the mixture of nitrogen gas and oxygen is heated, they interrelate to form NOX. The higher the combustion temperature, the more NOX will be formed. The largest source of NOX emission is road traffic. These emissions are reported to have doubled during the 1960s, approximately 22 million tons of NO2 are released every year in Europe. Certain types of fertilizer are another source of nitrogen pollution. Nitrate leaching intensified the acidification of the soil, which release unwanted substances such as aluminium (Thunberg, 1993).

2. The environmental effects of acidification

2. 1 water acidification and aquatic biota

Acidification was first noticed in the lakes. The initial victims of acidification are nutrient-deficient lakes in areas where the soil has a poor buffering ability (Thunberg, 1993). It is reported that many lakes in the Rocky Mountain have little alkalinity to buffer increase in acid deposition, however loss of alkalinity has been observed caused by high concentration of acid deposition due to the emission in the Rocky Mountain region (Turk et al, 1989).

Figure 3. Acidified lake: A deep blue colour of a lake is a sign of acidification. Source: ARIC (2000)

In severely acidified lake, the fish will have vanished entirely, bog moss will have spread out over the lake floor, and only few plant and animal species will remain. The first victims of acidification are crayfish, snails and mussels, certain types of zoo- and phytoplankton, and some species of mayfly. Usually, certain types of bog moss and insects those are resistant to acidification remains. This is not only low pH value that takes a heavy toll of fauna and flora. In acid lakes there are increased concentrations of aluminium in ion form, which is highly toxic to many organisms.

The loss of fauna / flora is due to the combination of a lowered pH and aluminium poisoning. The level of other heavy metals also rises such as cadmium, zinc, and lead. Those heavy metals including aluminium flow into lakes from the acidified soils of the surroundings. The relationship of prey

and predators will also change, for instance certain insects on which they usually prey begin to thrive when their predators are disappeared (Thunberg, 1993).

2. 2 Soil/water interactions

Acidification process takes place naturally in the soil. The plant releases hydrogen ions as it uptake nutrients. Though the growth itself is acidifying, there is no net acidification where growth and decay are about equal. However, the cycle is broken by harvesting, the acidifying process will take over. Soil acidification may have biological effects in the respects through lowering of the pH value, an increase in the levels of aluminium and other toxic compounds and a loss of plant nutrients due to increased leaching, consequently may lower drainage water pH (Thunberg, 1993). Moreover, Long-term

increase in nitrogen supply may be responsible for alterations in root and shoot growth of plants(Carrol et al, 2003).

Figure 5. Soil pH range source ANRA (2003)

2. 3 Effects of forestry practices

Forestry practices can cause the soil and water to become acidified in several ways. Forest growth change drainage water pathways to stream, and increase stream water acidity. Extensive clear cutting can also accelerate the acidification of surface water. Applying acidifying fertilizer also helps to acidify soil and water (Thunberg, 1993). Twelve years studies of acidification-induced chemical changes in soils of Norway spruce and Scot pine in

southern Sweden reveals that pH in mineral soil decreased on average 0. 17 units between 1988 and 1999. It is said that these changes in forest soil are mainly due to the extensive deposition of acidifying substances (sulphur and nitrogen compounds) during the latter part of the 20th century (Jï¿½nsson et al, 2003). In addition, atmospheric pollution directly damages forest itself. Since the early 1970s, West Germany has experienced a rapid and widespread decline in the health of its forest trees; especially sensitive species were affected by exposure to low levels of pollutants (Ling et al, 1987).

2. 5 Groundwater quality

Most of the precipitation sinks to some extent into the ground. The more permeable the soil, the more water dribbles down. Normally acid rain will become less acid as it penetrates through the ground. However, where the soil becomes acidified and has less ability to neutralize, the effect will be decrease until it finally ceases. It is unlikely that acid groundwater will be harmful to human health, however toxic heavy metals, such as aluminium and cadmium may appear at elevated level where highly acidic. These metals are harmful for human health (Thunberg, 1993).

3. Solutions

Solutions to the problems of acidification fall into two groups, which are cure and prevention. Remedial measures can be applied where the problems actually arise (i. e. soils and surface waters). Preventive measures can be applied at source (i. e. at point of emission of the sulphur and nitrogen oxides). The latter are expensive and the least acceptable to industry,

however they are in fact more effective, more sustainable, and more immediately required (Park, 1987). Causal treatment by reducing aciditying emissions is the primary goal in a long-term as preventive measures, however outcomes from this approach are still uncertain and recovery may be slow. Indicative treatment, involving the addition of neutralizing agent such as powdered limestone to affected environment is the only realistic remedy in the short-term, and has become a widespread practice in Europe (Thunberg, 1993).

3. 1 Short-term solutions

Remedial action should be taken after the problems happen. This requires not simply the elimination of symptoms of damage (i. e. restocking fish in acidified lakes, planting new trees); it also involves restoration of natural chemical balances to ensure that damage does not reappear. Some materials in nature have ability to buffer, or neutralize, or offset acid input. Lime and limestone are the most accepted of a range of chemicals that can be used to buffer acidic materials. Lime has been added normally by spraying from helicopter to catchments, soils and forests to alleviate damage and improve conditions for environment (Park, 1987). With regard to the lakes and streams, this raises pH value of the water and decrease in the levels of heavy metals. After the liming many species quickly return to their former habitat (Thunberg, 1993). This approach has been most widely investigated in Sweden (Park, 1987).

This measure had been made in UK as well. Stream chemistry and biological effect was monitored for 10 years after the catchments of three acidified

Welsh streams at Llyn Brianne were limed in 1987/88. This monitoring reveals that chemistry in treated streams changed significantly as mean annual pH increased from 5-5. 1 before liming to 6. 1-6. 2; mean annual aluminium concentrations decreased from 0. 15-0. 18 to 0. 05-0. 11 mg L-1, and calcium concentrations increased from 0. 8-2. 0 to 2. 4-4. 5 mg L-1. The abundance of Acid-sensive taxa in limed streams increased after treatment. Liming has also been used as a means of restoring acidified soils. This improves the productivity of croplands and forests.

However, liming can cause negative impacts on stream, such as fine CaCO3 deposited on the stream banthos. In addition, liming is an expensive 'cure' measure. Sweden spent approximately $10 million from 1980-1983 for liming. Moreover, it is not practical for many lakes and rives, for some streams it is no help at all. There is uncertainty in relation to the effect of liming in a long run. Many studies have undertaken for the effects of post liming over short timescales, yet little has known about the long-term effects. At least 10 years monitoring is recommended (Bradley et al, 2002). Liming is a interim measures that provide biological defence, however it does not attack the root caused of the problems. It has been said that 'a sort of artificial respiration for dead lakes and streams'. Therefore, real effective measures are long-term prevention deliberate through a sustained policy, rather than cure.

3. 2 Long-term solutions

The only way to solve the problem of acidification in the long run is to reduce emissions of pollutants. The central point of the political debate over acid

rain is the need to reduce rainfall acidity by controlling emission of SO2 and NOX at source, mainly from power stations and vehicles:

Reducing emissions of SO2 from power stations by:

> Burn less fossil fuel

> Switch to low-sulphur fuel

> Fuel desulphurisation

> Sulphur reduction at combustion

> Flue gas desulphurisation

> Disperse flue gases

Reducing emission of NOx from power stations by:

> Reduce NOx emissions during burning

> Reduce NOx levels after burning

Reducing emissions of NOx from vehicles by:

> Modify engines or exhausts to reduce emissions

> Change to different type of engine

> Transport planning

It is said thattechnologyof controlling and reducing such emissions already exist. Some methods should be applied separately or in combination to be

able to bring reduction to agreed levels within agreed time-scales. However, this problem is not only to do with a technical one. Political goodwill is essential as this measures involves high cost. All the cost should be offset by positive side-effects such as the creation of new jobs and generation of useful by-products (i. e. commercial sulphuric acid), the values of conserving fish, forest and crops, and benefits in improved human health (Park, 1987). In recent decades, there have been national and international efforts to achieve reduction in emissions of sulphur and nitrogen compounds to the atmosphere (Ferrier et at, 2001).

As previously mentioned, emissions of sulphur and Nitrogen are carried by air and deposited as gases and aerosols and dissolved in rainwater, in areas far from their sources. The quality of air is very much influenced by emissions in others, so it will benefit little for any country alone to reduce emissions. This is called transboundary Import-Export Budgets. Data for 1998 is presented in Appendix A Without international cooperation, there can be no real solution (Thunberg, 1993). The details of these treaties and protocols are presented in Appendix C

4. Improvement

Recent data shows that both emissions seem steadily declined particularly after these treaties and protocols noted above have adopted (See appendix B). However, compared to reduction of SO2 emission, NOX emission need to be reduced further, especially U. S, whose emission has not been much reduced.

Conclusion

Acidification has a long history as posing adverse impacts on various ecosystems and human health. The main sources of pollution are SO2 and NOX. These pollutants are naturally exist, however recent increases of these pollutants are caused by human-induced factors, such as power generation and transportation. Remedial measures have been taken to abate damaged environment by acid deposition. Preventive measures have been adopted for preventing further damages. In attempts to make steadily progress for both redemption and prevention for solution of acidification for water quality, use of combination of short-term and long-term solution will be recommended.