GK-12 Brooklyn College: City As Lab

ITAVA Group: Fall 2011: 45 minutes

Pollution

Objectives: Students will be able to:

- Read and analyze articles about pollution.
- Understand different types of pollution

Materials:

- Three different articles on Pollution: Chernobyl Disaster, Cyanide Spill at Baia Mare in Romania and BP Oil Spill

Procedure:

Aim: To Be Able to Better Understand Different Types of Pollution

Do Now: Student will be given a worksheet to answer questions such as:
Name of Article:
What is (are) the types of pollution discussed in your article?
What is responsible for this pollution?
How does this pollution affect people and the environment?
What efforts were made to prevent or reduce this pollution?

Split the class up into three groups and give each group one type of article on Pollution (one on Chernobyl Disaster, one on Cyanide Spill at Baia Mare in Romania and one on BP Oil Spill). Have the students read the article, and ask them to answer questions on the worksheet. They should work together within the group and discuss the article.

After the students have gotten through the Do Now, discuss with them their answers within each group. Ask them specific questions from the article. Make sure that the students were able to understand what the article was about and any hard concepts that they had trouble understanding.

Assessment:

Once you have discuses with each group their article, have them share the article with the rest of the class. Make sure they explain what the article is about and to go over all the questions in the Do Now.

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What Are the Different Types of Pollution?

Objectives: Students will be able to:

- Understand the main concepts of different types of the pollution, carbon dioxide cycle and carbon footprint
- Understand different methods to reduce pollution

Materials:

- PowerPoint Presentation of different types of the pollution, carbon dioxide cycle and carbon footprint, as well as to reduce pollution and how to reuse and recycle waste.

Procedure:

Aim: To Understand Different Types of Pollution

Do Now: Student will be given a worksheet to answer questions such as:

-Think of a way that you may be affected directly by pollution.

-How is this affecting you?

-What is the source of this pollution?

Give them ten minutes to answer all the questions and go over their answers with the class.

Assessment:

After the Do Now, go over different types of pollution, such as air, water, soil, noise and light pollution. Make sure they understand the difference between them, by using different examples. Have the students list brief description of different types of the pollution on the worksheet. As well, go over the carbon dioxide cycle and the carbon footprint. Give students better understanding of the carbon footprint by giving them a breakdown of typical person's carbon footprint. Ask them about their own carbon footprint (example, ask students how did they get to school, did they take the bus, did they drive to school; did they use any electronics in the morning, such as hair dryer, etc).

Once the students have better understanding of the carbon footprint, ask them what are some of the possibilities to reduce everyday pollution? Then go over how to reduce pollution and how to reuse and recycle waste. Give them specific examples from everyday life, such as the use of plastic bags or plastic bottles. After this, have the students think about other everyday items that can be reduced, reused and/or recycled. Ask them if they use any of the items and what are some of the ways or changes they can do to reduced, reused and/or recycle them.

THE ACCIDENT

On January 30 at 22:00, there was a break in a dam encircling a tailings pond at a facility operated by Aurul SA Company in Baia Mare, northwest Romania. The result was a spill of about 100,000 cubic meters of liquid and suspended waste containing about 50 to 100 tonnes of cyanide, as well as copper and other heavy metals. The break was probably caused by a combination of design defects in the facilities set up by Aurul, unexpected operating conditions and bad weather.

The contaminated spill travelled into the rivers Sasar, Lapus, Somes, Tisza and Danube before reaching the Black Sea about four weeks later. Some 2,000 kilometres of the Danube's water catchment area were affected by the spill.

Romanian sources said that, in Romania, the spill caused interruptions to the water supply of 24 municipalities, and costs to sanitation plants and industries, because of interruptions in their production processes. Romania also reported that the amount of dead fish was very small in Romania. Hungary estimated the amount of dead fish in Hungary at 1,240 tonnes. Yugoslavian authorities reported large amounts of dead fish in the Yugoslavian branch of the Tisza River and no major fish kills in the Danube River.

THE MISSION

On February 18, 2000, Klaus Toepfer, Executive Director of the United Nations Environment Programme (UNEP), announced that a team of international experts would carry out a mission to analyse the damages caused by the spill.

The announcement followed requests made by the governments of Romania, Hungary and Yugoslavia and consultations with the European Union's Environment Commissioner, Margot Wallström, and the UN Office for the Co-ordination of Humanitarian Affairs (OCHA).

The mission, a joint venture of UNEP and OCHA, lasted from February 23 to March 6. It included sampling, analysis and discussions with national and local experts, national authorities, affected populations and NGOs. The team travelled from Bucharest to Baia Mare in Romania, then through Hungary along the river system down to Yugoslavia, to the mouth of the Danube River at the Black Sea.

BAIA MARE AND MARAMURES COUNTY

Maramures County, where the town of Baia Mare is located, lies at Romania's northwestern border with Ukraine and Hungary.

It has a long history of mining, especially in gold, silver, lead, zinc, copper, manganese and salt. Waste at the county's seven key mining sites is stored in ponds and 215 waste ("tailings") dams.

The county has high levels of chronic ("persistently recurring") soil, water and air contamination that comes from many pollutants. These were released over decades of past industrial activities that used environmentally unsound technologies. This includes an old lead smelter, copper smelter, sulphuric acid plant, and the operations of the mining company, Romanian Compania Nationala a Metalelor Pretiosasi si Neferoase (Remin), established in 1992.

Some Baia Mare residents live within 50 metres of highly toxic, chronically leaking, waste sites. The World Health Organization (WHO) identifies Baia Mare as a health risk hotspot, with the population's exposure to lead being among the highest ever recorded. Lead in the blood of some adults averages almost 2.5 times above safety levels. In some children, it averages nearly six times above safety levels. High lead levels in humans are now thought to be associated with impaired learning ability, mental retardation, problems with kidney and neurological functions, hearing loss, blood disorder, hypertension and death. Baia Mare residents have complained about dust from industrial processes for some time.

It is also important to know that the city of Baia Mare's population and urban development are growing, with expansion restricted in some areas by old contaminated tailings ponds.

THE COMPANY: AURUL SA

Aurul SA is a stock company jointly owned by Esmeralda, Exploration Limited, Australia, and Remin, Romania. Over a seven-year period, Aurul obtained all of the necessary environmental permits required under Romanian law for its plant in Baia Mare, before beginning operations in May 1999.

It was hoped that the Aurul project would meet the needs of both the Romanian authorities and the Australian investors. Aurul would gain profits through its mining operations and local authorities would benefit from Aurul's management and removal of Baia Mare's old contaminated ponds, which blocked further development in the city.

The process and technologies used at the Baia Mare plant for recovering precious metals were completely new to Romania and were expected to be the most modern, safe and efficient in the region and a major environmental improvement.

The Baia Mare plant was designed to process 2.5 million tonnes of tailings per year — to recover about 1.6 tonnes of gold and 9 tonnes of silver per year. The project was to last 10 to 12 years, although this may increase due to recent business deals made with Romanian companies.

The tailings, originating from earlier mining activities and stored next to Baia Mare, contain small amounts of precious metals, especially gold and silver. Aurul's process uses high concentrations of cyanide to remove the precious metals from the tailings. As part of the process, tailings are transported 6.5 kilometres away from Baia Mare to a new dam near Bozanta Mare village. The process was designed to release no waste to the surrounding environment.

Unfortunately, the mission could not determine how often the plant had been inspected by government authorities before the spill occurred. Soon after operations began in 1999, however, two leaks were reported in Aurul's pipeline system.

Background

FACTS ON DANGEROUS SUBSTANCES

n **Cyanide**

Cyanide is acutely and almost instantaneously poisonous ("toxic") to living organisms, including humans. Cyanide harms by blocking the ingestion of oxygen by cells. Acute effects include rapid breathing, tremors, effects on the nervous system, and ultimately, death. Chronic effects include weight loss, effects on the thyroid and nerve damage.

Fish are about one thousand times more sensitive to cyanide than humans. If fish do not die from limited exposure, they can still have reduced swimming ability, problems in reproducing (possibly creating deformed babies), and increased vulnerability to predators. Fish are excellent in gauging the presence of cyanide in water — if fish are living after exposure, then no other form of life will have been harmed. Cyanide, however, does not remain in the environment for long and does not accumulate in sediments or organisms (including humans).

n **Heavy metals**

Heavy metals do not break down and are "bio-accumulative" in plants, animals and the environment. This means that the level of toxins builds up in an organism over time, increasing its toxicity and threat to local ecosystems. Toxins may also be passed on to other species if a toxic organism is eaten. Therefore, living organisms face high risks with long-term and chronic exposure to heavy metals.

Among the heavy metals used by mining industries, the most harmful to humans include arsenic, cadmium, lead, nickel, manganese and molybdenum, even at small doses. Zinc, lead, aluminum, boron, chromium and iron are also all toxic to plant growth.

The acute and chronic effects of copper to humans include stomach and intestinal distress, liver and kidney damage and anemia. Copper is also toxic to most aquatic plants, often contained in river sediments. Copper easily dissolves in water so it is more available for uptake by living things along rivers.

At relatively low levels, health effects from lead can include interference with red blood cell chemistry, delays in normal physical and mental development in babies and young children, slight deficits in the attention span, interference with hearing and learning abilities of children, and slight increases in the blood pressure of some adults. Changes in the levels of certain blood enzymes and in child development may even occur at very low blood lead levels. Chronic exposure to lead has been linked to brain and kidney disease and cancer in humans.

Assessment

CAUSE OF ACCIDENT

The breakage in the Aurul dam was partially caused by heavy rains and rapidly melting snows that made the water level in the pond rise. This rise was quicker than the rise of the dam which was intended to "grow gradually over time" as additional tailings accumulated.

The newly engineered dam system therefore failed under the circumstances, and this could have been foreseen. There were no plans to deal with such a rise in water or to catch overflow wastewater. A completely closed operation with no discharges to the environment was thus not possible under the conditions. Furthermore, the operation was actually open at two points, at the old and the new ponds, which allowed unmonitored amounts of cyanide to be regularly lost into the air and/or groundwater.

At the same time, Aurul was operating in line with government permits. Under Romanian law, the plant and ponds, categorised as "regular" risk, did not require any special emergency planning or monitoring to detect dangerous situations. Accident plans did exist but were not sufficient.

The mission therefore believed that both the company and local authorities had inadequate plans and responses in place for emergencies, considering the large quantities of hazardous materials being used close to human populations and the river system.

GOVERNMENT RESPONSE

In Romania, about ten hours were lost between the time the Baia Mare Environmental Protection Agency received notification of the spill from Aurul and the time the local Romanian Waters Authority was informed. As a result, local residents near the source of the spill were not informed as early as possible.

Once the Romanian Water Authority was informed, however, their regional environment and water authorities immediately checked information about the breach and the spill to determine the degree of pollution, and ordered Aurul to stop activities and close the breakage. They also informed the Water and Environmental Protection Agency of Nyiregyhaza (Hungary) about the accident, and alerted local authorities downstream about the spill and dangers in using the river water for activities such as drinking.

The Romanian Principal International Alert Center (PIAC) notified the Hungarian PIAC on January 31 at 20:54. It also informed Bulgaria, Moldova, Ukraine and Yugoslavia. According to international law, PIACs must be informed as soon as there is a sudden increase of hazardous substances in the Danube River Basin. The mission found that this early warning system responded adequately to the spill.

Hungarian authorities confirmed that they were continuously informed about the event and the degree of pollution by Romanian authorities. This allowed them to alert all regional and local authorities in a timely manner and to take the necessary measures to minimise the impact of the spill. Measures taken by the Hungarian side included warnings to the public, operations at dams and ponds to protect aquifers and side branches, the temporary closure of the Kiskore dam (along the upper Tisza) to increase the water level and temporary closure of the water intake from the Tisza River to the town of Szolnok. The dam was reopened when the contaminated water arrived, speeding up

Chernobyl Nuclear Disaster Revisited

Part one of a series

By Roberta C. Barbalace

Chernobyl Disaster Recalled

At 1:23 AM on April 26, 1986, two explosions ripped through the Unit 4 reactor of the Chernobyl Nuclear Power Plant in the Ukraine. The reactor block and adjacent structure were wrecked by the initial explosion. Nearby buildings were ignited by burning graphite projectiles. Radioactive particles swept across the Ukraine, Belarus, the western portion of Russia and eventually spread across Europe and the whole Northern Hemisphere. The accident followed a safety experiment in which the plant was operated outside of its designed parameters at very low power and unfavorable cooling conditions.

The graphite fires continued to burn for several days despite the fact that thousands of tons of boron carbide, lead, sand and clay were dumped over the core reactor by helicopter. The fire eventually extinguished itself when the core melted, flowed into the lower part of the building and then solidified, sealing off the entry. About 71% of the radioactive fuel in the core (about 135 metric tons) remained uncovered for about 10 days until cooling and solidification took place. 135,000 people were evacuated from a 30-km radius exclusion zone. Clean up involved some 800,000 people. The radioactivity released was estimated to be about two hundred times that of the combined releases in the bombing of Hiroshima and Nagasaki. Millions of people were exposed to the radiation in varying doses.

Health Consequences of the Chernobyl Disaster

Compulsory health monitoring was provided to those who lived and worked in the heavily contaminated area. Health monitoring was also provided for more than 4.5 million people who were exposed to lower levels of radiation. Still, the available information on the direct health effects of the catastrophe are sketchy at best.

Twenty different radionuclides with half-lives varying from 8 days to 24,400 years were released into the atmosphere during the ten day period following the explosion. The contaminants include idiodine-131, cesium-134 and -137 and several plutonium isotopes. There were 444 workers at the site at the time of the accident. Of the 300 admitted to hospitals, 134 were diagnosed with acute radiation syndrome (ARS). Only 45 of these individuals have died to date, though the survivors still suffer with emotional and sleep disturbances and 30% have gastrointestinal, cardiovascular and immuno-function disorders. In Belarus alone 2.2 million people including 600,000 juveniles and children have been exposed to the prolonged impact of long-lived radionuclides. A total of 415 settlements have been evacuated, and the 130,000 residents resettled, making monitoring of them difficult.

The actual death toll due to this catastrophe is hard to determine. Greenpeace Ukraine estimates the total number to be about 32,000. Some estimates are higher, many are much lower. The rate of thyroid cancer in children up to the age of 15 has increased 200 fold in Gomel Oblast, Belarus since the accident. At least 90% of these are curable, but the number of cases is expected to increase, especially in children like Blasa who were younger than three at the time of the release. Thyroid cancer is due to inhalation of radioactive iodine or ingestion from drinking milk from cows that have eaten grass that is contaminated with radioactive particles. Iodine-134 is absorbed and concentrated (biointensified) in the milk. When humans drink the milk, the iodine-134 becomes incorporated almost exclusively in the thyroid gland. Many diets in the fall-out affected area of the former Soviet Union are typically deficient in iodine. Individuals who had low levels of iodine in their diet incorporated large quantities of the radioactive iodine into their system as their bodies attempted to compensate for the deficiency. At the moment few republics are reporting a rise in leukemia, a condition which would have been expected to increase. It is possible that the actual rise in incidents of the disease is masked by the mass resettlement into other unaffected areas after the accident. This may have resulted in skewed results since any increase in the rate of leukemia would be averaged over a larger population of individuals, many of whom had not been exposed.

The incidences of birth defects have increased in heavily contaminated areas. A condition known as "minisatellite mutation" in the Mogilev district of Belarus is "unusually high."

Most genetic mutations resulting from exposure to radiation are recessive and are not likely to be expressed until the individuals affected have grandchildren. The mutation will be fully manifested when two people carrying the same mutant gene marry and produce a child who receives the identical mutant gene from each parent (a one-in-four chance for each child they produce). Radiation effects are dependent upon both level and time of exposure and some individuals continue to be exposed. As a result many effects of radiation on an exposed individual may not be manifested for years to come. Madame Curie reportedly worked with radioactive materials for years before she finally succumbed to its effects. Cancer may take many years to develop after exposure to a carcinogen.

The secondary effects of the accident are readily obvious. Millions of people are suffering from mental and emotional illness and these conditions lead to disturbances of the physical kind, including digestive disorders, high blood pressure, heart conditions and more generally sleeplessness and alcoholism. General living conditions in the three affected republics are substandard. The economy is deteriorating and health services are experiencing total collapse. People are malnourished, and diseases like tuberculosis are on the increase. Some of this economic depression is due to the accident, and some is a result of the general economic situation in the former Soviet Union as a whole. The immediate problems are more important to them than diseases that will not have a major impact until some time in the future. As a result, leukemia, thyroid cancer and birth defects must take a back seat to more pressing issues, such as basic survival. Extensive studies will be necessary in order to determine the total impact of the Chernobyl disaster and approach a solution intelligently.

The Bhopal disaster and its aftermath: a review

Edward Broughton [1]
[1]Columbia University, Mailman School of Public Health, 600 W 168th St. New York, NY 10032 USA
Corresponding author.
Edward Broughton: eib6@columbia.edu
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Abstract

On December 3 1984, more than 40 tons of methyl isocyanate gas leaked from a pesticide plant in Bhopal, India, immediately killing at least 3,800 people and causing significant morbidity and premature death for many thousands more. The company involved in what became the worst industrial accident in history immediately tried to dissociate itself from legal responsibility. Eventually it reached a settlement with the Indian Government through mediation of that country's Supreme Court and accepted moral responsibility. It paid $470 million in compensation, a relatively small amount of based on significant underestimations of the long-term health consequences of exposure and the number of people exposed. The disaster indicated a need for enforceable international standards for environmental safety, preventative strategies to avoid similar accidents and industrial disaster preparedness.

Since the disaster, India has experienced rapid industrialization. While some positive changes in government policy and behavior of a few industries have taken place, major threats to the environment from rapid and poorly regulated industrial growth remain. Widespread environmental degradation with significant adverse human health consequences continues to occur throughout India.

December 2004 marked the twentieth anniversary of the massive toxic gas leak from Union Carbide Corporation's chemical plant in Bhopal in the state of Madhya Pradesh, India that killed more than 3,800 people. This review examines the health effects of exposure to the disaster, the legal response, the lessons learned and whether or not these are put into practice in India in terms of industrial development, environmental management and public health.

History

In the 1970s, the Indian government initiated policies to encourage foreign companies to invest in local industry. Union Carbide Corporation (UCC) was asked to build a plant for the manufacture of Sevin, a pesticide commonly used throughout Asia. As part of the deal, India's government insisted that a significant percentage of the investment come from local shareholders. The government itself had a 22% stake in the company's subsidiary, Union Carbide India Limited (UCIL) . The company built the plant in Bhopal because of its central location and access to transport infrastructure. The specific site within the city was zoned for light industrial and commercial use, not for hazardous industry. The plant was initially approved only for formulation of pesticides from component chemicals, such as MIC imported from the parent company, in relatively small quantities. However, pressure from competition in the chemical industry led UCIL to implement "backward integration" – the manufacture of raw materials and intermediate products for formulation of the final product within one facility. This was inherently a more sophisticated and hazardous process .

In 1984, the plant was manufacturing Sevin at one quarter of its production capacity due to decreased demand for pesticides. Widespread crop failures and famine on the subcontinent in the 1980s led to increased indebtedness and decreased capital for farmers to invest in pesticides. Local managers were directed to close the plant and prepare it for sale in July 1984 due to decreased profitability. When no ready buyer was found, UCIL made plans to dismantle key production units of the facility for shipment to another developing country. In the meantime, the facility continued to operate with safety equipment and procedures far below the standards found in its sister plant in Institute, West Virginia. The local government was aware of safety problems but was reticent to place heavy industrial safety and pollution control burdens on the struggling industry because it feared the economic effects of the loss of such a large employer .

At 11.00 PM on December 2 1984, while most of the one million residents of Bhopal slept, an operator at the plant noticed a small leak of methyl isocyanate (MIC) gas and increasing pressure inside a storage tank. The vent-gas scrubber, a safety device designer to neutralize toxic discharge from the MIC system, had been turned off three weeks prior. Apparently a faulty valve had allowed one ton of water for cleaning internal pipes to mix with forty tons of MIC . A 30 ton refrigeration unit that normally served as a safety component to cool the MIC storage tank had been drained of its coolant for use in another part of the plant. Pressure and heat from the vigorous exothermic reaction in the tank continued to build. The gas flare safety system was out of action and had been for three months. At around 1.00 AM, December 3, loud rumbling reverberated around the plant as a safety valve gave way sending a plume of MIC gas into the early morning air. Within hours, the streets of Bhopal were littered with human corpses and the carcasses of buffaloes, cows, dogs and birds. An estimated 3,800 people died immediately, mostly in the poor slum colony adjacent to the UCC plant. Local hospitals were soon overwhelmed with the injured, a crisis further compounded by a lack of knowledge of exactly what gas was involved and what its effects were. It became one of the worst chemical disasters in history and the name Bhopal became synonymous with industrial catastrophe.

Estimates of the number of people killed in the first few days by the plume from the UCC plant run as high as 10,000, with 15,000 to 20,000 premature deaths reportedly occurring in the subsequent two decades. The Indian government reported that more than half a million people were exposed to the gas. Several epidemiological studies conducted soon after the accident showed significant morbidity and increased mortality in the exposed population. Table Table1.1. summarizes early and late effects on health. These data are likely to under-represent the true extent of adverse health effects because many exposed individuals left Bhopal immediately following the disaster never to return and were therefore lost to follow-up.

Table 1

Health effects of the Bhopal methyl isocyanate gas leak exposure [8, 30-32].

Early effects (0–6 months)	
Ocular	Chemosis, redness, watering, ulcers, photophobia
Respiratory	Distress, pulmonary edema, pneumonitis, pneumothorax
Gastrointestinal	Persistent diarrhea, anorexia, persistent abdominal pain
Genetic	Increased chromosomal abnormalities
Psychological	Neuroses, anxiety states, adjustment reactions
Neurobehavioral	Impaired audio and visual memory, impaired vigilance attention and response time, impaired reasoning and spatial ability, impaired psychomotor coordination
Late effects (6 months onwards)	
Ocular	Persistent watering, corneal opacities, chronic conjunctivitis
Respiratory	Obstructive and restrictive airway disease, decreased lung function

Table 1

Health effects of the Bhopal methyl isocyanate gas leak exposure [8, 30-32].

Aftermath

Immediately after the disaster, UCC began attempts to dissociate itself from responsibility for the gas leak. Its principal tactic was to shift culpability to UCIL, stating the plant was wholly built and operated by the Indian subsidiary. It also fabricated scenarios involving sabotage by previously unknown Sikh extremist groups and disgruntled employees but this theory was impugned by numerous independent sources.

The toxic plume had barely cleared when, on December 7, the first multi-billion dollar lawsuit was filed by an American attorney in a U.S. court. This was the beginning of years of legal machinations in which the ethical implications of the tragedy and its affect on Bhopal's people were largely ignored. In March 1985, the Indian government enacted the Bhopal Gas Leak Disaster Act as a way of ensuring that claims arising from the accident would be dealt with speedily and equitably. The Act made the government the sole representative of the victims in legal proceedings both within and outside India. Eventually all cases were taken out of the U.S. legal system under the ruling of the presiding American judge and placed entirely under Indian jurisdiction much to the detriment of the injured parties.

In a settlement mediated by the Indian Supreme Court, UCC accepted moral responsibility and agreed to pay $470 million to the Indian government to be distributed to claimants as a full and final settlement. The figure was partly based on the disputed claim that only 3000 people died and 102,000 suffered permanent disabilities. Upon announcing this settlement, shares of UCC rose $2 per share or 7% in value. Had compensation in Bhopal been paid at the same rate that asbestosis victims were being awarded in US courts by defendant including UCC – which mined asbestos from 1963 to 1985 – the liability would have been greater than the $10 billion the company was worth and insured for in 198 4. By the end of October 2003, according to the Bhopal Gas Tragedy Relief and Rehabilitation Department, compensation had been awarded to 554,895 people for injuries received and 15,310 survivors of those killed. The average amount to families of the dead was $2,200.

At every turn, UCC has attempted to manipulate, obfuscate and withhold scientific data to the detriment of victims. Even to this date, the company has not stated exactly what was in the toxic cloud that enveloped the city on that December night. When MIC is exposed to 200° heat, it forms degraded MIC that contains the more deadly hydrogen cyanide (HCN). There was clear evidence that the storage tank temperature did reach this level in the disaster. The cherry-red color of blood and viscera of some victims were characteristic of acute cyanide poisoning. Moreover, many responded well to administration of sodium thiosulfate, an effective therapy for cyanide poisoning but not MIC exposure. UCC initially recommended use of sodium thiosulfate but withdrew the statement later prompting suggestions that it attempted to cover up evidence of HCN in the gas leak. The presence of HCN was vigorously denied by UCC and was a point of conjecture among researchers.

As further insult, UCC discontinued operation at its Bhopal plant following the disaster but failed to clean up the industrial site completely. The plant continues to leak several toxic chemicals and heavy metals that have found their way into local aquifers. Dangerously contaminated water has now been added to the legacy left by the company for the people of Bhopal.

Lessons learned

The events in Bhopal revealed that expanding industrialization in developing countries without concurrent evolution in safety regulations could have catastrophic consequences. The disaster demonstrated that seemingly local problems of industrial hazards and toxic contamination are often tied to global market dynamics. UCC's Sevin production plant was built in Madhya Pradesh not to avoid environmental regulations in the U.S. but to exploit the large and growing Indian pesticide market. However the manner in which the project was executed suggests the existence of a double standard for multinational corporations operating in developing countries. Enforceable uniform international operating regulations for hazardous industries would have provided a mechanism for significantly improved in safety in Bhopal. Even without enforcement, international standards could provide norms for measuring performance of individual companies engaged in hazardous activities such as the manufacture of pesticides and other toxic chemicals in India. National governments and international agencies should focus on widely applicable techniques for corporate responsibility and accident prevention as much in the developing world context as in advanced industrial nations. Specifically, prevention should include risk reduction in plant location and design and safety legislation.

Local governments clearly cannot allow industrial facilities to be situated within urban areas, regardless of the evolution of land use over time. Industry and government need to bring proper financial support to local communities so they can provide medical and other necessary services to reduce morbidity, mortality and material loss in the case of industrial accidents.

Public health infrastructure was very weak in Bhopal in 1984. Tap water was available for only a few hours a day and was of very poor quality. With no functioning sewage system, untreated human waste was dumped into two nearby lakes, one a source of drinking water. The city had four major hospitals but there was a shortage of physicians and hospital beds. There was also no mass casualty emergency response system in place in the city. Existing public health infrastructure needs to be taken into account when hazardous industries choose sites for manufacturing plants. Future management of industrial development requires that appropriate resources be devoted to advance planning before any disaster occurs. Communities that do not possess infrastructure and technical expertise to respond adequately to such industrial accidents should not be chosen as sites for hazardous industry.

Since 1984

Following the events of December 3 1984 environmental awareness and activism in India increased significantly. The Environment Protection Act was passed in 1986, creating the Ministry of Environment and Forests (MoEF) and strengthening India's commitment to the environment. Under the new act, the MoEF was given overall responsibility for administering and enforcing environmental laws and policies. It established the importance of integrating environmental strategies into all industrial development plans for the country. However, despite greater government commitment to protect public health, forests, and wildlife, policies geared to developing the country's economy have taken precedence in the last 20 years.

India has undergone tremendous economic growth in the two decades since the Bhopal disaster. Gross domestic product (GDP) per capita has increased from $1,000 in 1984 to $2,900 in 2004 and it continues to grow at a rate of over 8% per year. Rapid industrial development has contributed greatly to economic growth but there has been significant cost in environmental degradation and increased public health risks. Since abatement efforts consume a large portion of India's GDP, MoEF faces an uphill battle as it tries to fulfill its mandate of reducing industrial pollution. Heavy reliance on coal-fired power plants and poor enforcement of vehicle emission laws have result from economic concerns taking precedence over environmental protection.

With the industrial growth since 1984, there has been an increase in small scale industries (SSIs) that are clustered about major urban areas in India. There are generally less stringent rules for the treatment of waste produced by SSIs due to less waste generation within each individual industry. This has allowed SSIs to dispose of untreated wastewater into drainage systems that flow directly into rivers. New Delhi's Yamuna River is illustrative. Dangerously high levels of heavy metals such as lead, cobalt, cadmium, chrome, nickel and zinc have been detected in this river which is a major supply of potable water to India's capital thus posing a potential health risk to the people living there and areas downstream.

Land pollution due to uncontrolled disposal of industrial solid and hazardous waste is also a problem throughout India. With rapid industrialization, the generation of industrial solid and hazardous waste has increased appreciably and the environmental impact is significant.

India relaxed its controls on foreign investment in order to accede to WTO rules and thereby attract an increasing flow of capital. In the process, a number of environmental regulations are being rolled back as growing foreign investments continue to roll in. The Indian experience is comparable to that of a number of developing countries that are experiencing the environmental impacts of structural adjustment. Exploitation and export of natural resources has accelerated on the subcontinent. Prohibitions against locating industrial facilities in ecologically sensitive zones have been eliminated while conservation zones are being stripped of their status so that pesticide, cement and bauxite mines can be built. Heavy reliance on coal-fired power plants and poor enforcement of vehicle emission laws are other consequences of economic concerns taking precedence over environmental protection.

In March 2001, residents of Kodaikanal in southern India caught the Anglo-Dutch company, Unilever, red-handed when they discovered a dumpsite with toxic mercury laced waste from a thermometer factory run by the company's Indian subsidiary, Hindustan Lever. The 7.4 ton stockpile of mercury-laden glass was found in torn stacks spilling onto the ground in a scrap metal yard located near a school. In the fall of 2001, steel from the ruins of the World Trade Center was exported to India apparently without first being tested for contamination from asbestos and heavy metals present in the twin tower debris. Other examples of poor environmental stewardship and economic considerations taking precedence over public health concerns abound.

The Bhopal disaster could have changed the nature of the chemical industry and caused a reexamination of the necessity to produce such potentially harmful products in the first place. However the lessons of acute and chronic effects of exposure to pesticides and their precursors in Bhopal has not changed agricultural practice patterns. An estimated 3 million people per year suffer the consequences of pesticide poisoning with most exposure occurring in the agricultural developing world. It is reported to be the cause of at least 22,000 deaths in India each year. In the state of Kerala, significant mortality and morbidity have been reported following exposure to Endosulfan, a toxic pesticide whose use continued for 15 years after the events of Bhopal.

Aggressive marketing of asbestos continues in developing countries as a result of restrictions being placed on its use in developed nations due to the well-established link between asbestos products and respiratory diseases. India has become a major consumer, using around 100,000 tons of asbestos per year, 80% of which is imported with Canada being the largest overseas supplier. Mining, production and use of asbestos in India is very loosely regulated despite the health hazards. Reports have shown morbidity and mortality from asbestos related disease will continue in India without enforcement of a ban or significantly tighter controls.

UCC has shrunk to one sixth of its size since the Bhopal disaster in an effort to restructure and divest itself. By doing so, the company avoided a hostile takeover, placed a significant portion of UCC's assets out of legal reach of the victims and gave its shareholder and top executives bountiful profits. The company still operates under the ownership of Dow Chemicals and still states on its website that the Bhopal disaster was "cause by deliberate sabotage".

Some positive changes were seen following the Bhopal disaster. The British chemical company, ICI, whose Indian subsidiary manufactured pesticides, increased attention to health, safety and environmental issues following the events of December 1984. The subsidiary now spends 30–40% of their capital expenditures on environmental-related projects. However, they still do not adhere to standards as strict as their parent company in the UK.

The US chemical giant DuPont learned its lesson of Bhopal in a different way. The company attempted for a decade to export a nylon plant from Richmond, VA to Goa, India. In its early negotiations with the Indian government, DuPont had sought and won a remarkable clause in its investment agreement that absolved it from all liabilities in case of an accident. But the people of Goa were not willing to acquiesce while an important ecological site was cleared for a heavy polluting industry. After nearly a decade of protesting by Goa's residents, DuPont was forced to scuttle plans there. Chennai was the next proposed site for the plastics plant. The state government there made significantly greater demand on DuPont for concessions on public health and environmental protection. Eventually, these plans were also aborted due to what the company called "financial concerns".

Conclusion

The tragedy of Bhopal continues to be a warning sign at once ignored and heeded. Bhopal and its aftermath were a warning that the path to industrialization, for developing countries in general and India in particular, is fraught with human, environmental and economic perils. Some moves by the Indian government, including the formation of the MoEF, have served to offer some protection of the public's health from the harmful practices of local and multinational heavy industry and grassroots organizations that have also played a part in opposing rampant development. The Indian economy is growing at a tremendous rate but at significant cost in environmental health and public safety as large and small companies throughout the subcontinent continue to pollute. Far more remains to be done for public health in the context of industrialization to show that the lessons of the countless thousands dead in Bhopal have truly been heeded.

GK-12 Brooklyn College: City as Lab
ITAVA Group: Spring 2012: 45 minutes

How are we affected by excessive noise?

Objectives: Students will be able to…

- Understand the basic concepts of what sound is.
- Describe the harmful effects of excessive noise
- Begin organizing the data collected on the subway

Materials:

- Noise level data collected on the previous field trip
- Accompanying worksheet

Procedure:

Aim: How are we affected by excessive noise?

Do Now: Name possible sources of excess noise in your everyday life. How long do you think you are exposed to these conditions on a daily basis?

Lesson:
The accompanying power point presentation will go through some basics on sound and noise pollution, and how it affects our hearing. As we go through this power point the students are going to fill in some of the questions on the worksheet to help them keep track of major concepts.

Activity:
The students will be asked to start organizing the data they collected on the trains last week. First we will explain how we are going to organize our data, based on what information we are trying to relay. Then we will give students a template for organizing their data into a format that will be easily understandable, and simple. At this point, students will go into the groups they collected the data in and will start organizing their data with the given template, to be continued in the following class. As the students are organizing their data, the fellows and teacher will go around to make sure it is being done correctly, and to guide the students through any confusion.

Assessment:
When there is about 5-10 minutes left in class, have the students present as much of the data as they have gone through, and ask them to assess whether the noise levels are at a healthy level on an average commute, or not, and to be able to reference the noise health standards to explain their assessment.

GK-12 Brooklyn College: City as Lab
ITAVA Group: Spring 2012: 45 minutes (2 classes)

Calculating the Car Emission of Carbon Dioxide

Objectives: Students will be able to…
- Understand how to convert length, calculate gas mileage for each car type
- Understand how to calculate the amount of carbon dioxide emitted by cars based on the type of the car and the amount of the gasoline

Materials:
- Accompanying worksheet and power point.
- Collected data from the Carbon Footprint Project.

Procedure:

Worksheet : Calculating the Carbon Footprint of the Cars

Aim: How to calculate how much CO_2 is being emitted by the cars.

Lesson:
The power point presentation will go through the basics of how to calculate the carbon dioxide emission of cars. The power point will explain the following:
-how to convert the length into mileage
-how many gallons of gasoline are being used per block
-how much gasoline is burned by different types of cars
-how many grams of carbon dioxide are being emitted per gallon of gasoline
-how much carbon dioxide is being emitted on the block per car

Activity:
First we will go over the power point presentation. After all of the main issues are explained in calculating the carbon footprint of the cars, the students will be divided into three groups. Each group will organize and calculate the data collected from the Carbon Footprint Project.

Assessment:
When there is about 10 minutes left in class, have the students present as much of the calculated data with the rest of the class, by comparing and analyzing their results.

GK-12 Brooklyn College: City As Lab

ITAVA Group: Fall 2011: 45 minutes

Introduction to Field Work

Objectives: Students will be able to

- Understand the individual responsibilities each group will have
- Come up with ways to collect data when in the field
- Learn techniques that will be used in the field.

Materials:

- 3 sets of worksheets (one set per group) (at end of lesson plan)
- Decibel meter
- Measuring tapes
- Clicker counters

Procedure:

Aim: How will we collect the necessary data to complete our project?

Do Now: Remind the students of the project at hand, and what data is going to be collected. (Comparing two neighborhoods pollution levels and carbon footprint, using noise levels, car counts, and tree measurements) Now Divide the students into the groups that they will be in for the project. Each group has its own worksheet to help it establish how it will be collecting the data, and what they will actually be doing.

Ideally, each group can have a teacher to help guide the students through the worksheets. However, if not enough teachers are present go around to the different groups providing help where needed.

By the end of the lesson, this is what each group should have established:

Tree measurement group:

- How they are going to plot their data on a map
- How to using the apparent height method to measure height

Car Counting group:

- 5 car categories (small cars, big cars/vans, box truck, bus, and semi trucks)
- An average Miles per gallon for each category (can be obtained on the internet, by finding an average of vehicles of that type, and using an average model year.)

- A relatively simple way to figure out the length of the block they are counting cars from.

Noise Level Group:

- How the data is going to be organized and represented on the map (taking a measurement at different spots on a block and getting the average for each block.)

Assessment:

Once each group has gone through the worksheet, they will discuss what they have established with the rest of the class and explain the field techniques they have practiced and learned about.

Tree Measurement Team: Intro to measuring

1: What are the two units of measurement present on the tape measure you are using?

2: How do you suggest we should represent the trees on a map?

Practice Measuring:

Measure the height of your other group members, and compare you answer to those of you other group members.

Group Member 1 height:

Group Member 2 height:

Group Member 3 height:

Group Member 4 height:

Practice measuring circumference.

Pick an object in the room that is circular around the sides, and use your tape measure to measure the circumference of this object. Compare your results to those of your group members.

Circumference of object:

Practice Apparent height

Measure the height of the ceiling using the apparent height method. Have one person stand against the wall holding the tape measure so that it hangs down 1 meter to the floor, and have someone else standing farther away adjust their vision to make 1 cm equal to the 1 m long tape measure. The calculate the height of the ceiling in centimeters, then convert to meters. Compare you results to those of your team mates, and find the average.

Height of Ceiling:

Member 1: Member 2:

Member 3: Member 4:

Average Height of Ceiling:

Car Counting Team

Look at the counters and get used to how they work. Practice counting something (how many cars pass by outside the windows, how many squirrels you can see, etc.)

We are going to be counting different types of cars to be able to measure their emissions more specifically. Come up with 5 Categories of different cars types to count.

Categories

1:

2:

3:

4:

5:

In order to be able to calculate emissions, we need to figure out the average miles per gallon for each of these car types. We also need to measure the length of the block we will be counting cars on, in order to be able to properly calculate emissions.

Go to a computer that has an internet connection and try to search online for the average miles (or kilometer) per gallon for the different types of cars.

Miles per gallon for category

1:

2:

3:

4:

5:

Now try to come up with a way to measure the length of the block.

Noise Level Team

Before we start taking measurement, we have to figure out how we are going organize all the measurements. Come up with a way to organize the data you will be collecting:

Look at the Sound Level Meter and get used to how it works.

Measure the noise level at different corners of the room and at the center of the room, using the Max Hold button. Hold the button for 30 second and record the average:

1.

2.

3.

4.

Center of the Room:

Compare the noise level of the room to the actual standards.

OSHA Daily Permissible Noise Level Exposure	
Hours per day	Sound level
8	90dB
6	92dB
4	95dB
3	97dB
2	100dB
1.5	102dB
1	105dB
.5	110dB
.25 or less	115dB

GK-12 Brooklyn College: City as Lab
ITAVA Group: Spring 2012: 45 minutes (2 lessons)

Calculating Tree Sequestration and Human Carbon Dioxide Emission

Objectives: Students will be able to…

- Understand how to calculate human carbon dioxide emission and tree sequestration.
- Understand what a population density is.
- Understand the concept and the difference between photosynthesis and respiration.

Materials:

- Accompanying worksheet and power point.
- Collected data from the Carbon Footprint Project.
- Population density census of two measured neighborhoods.

Procedure:

Worksheet 1: Calculating Tree Sequestration
Worksheet 2: Calculating Population Density

Aim: How to Calculate Human Carbon Dioxide Emission and Tree Sequestration

Lesson:
The power point presentation will go through what photosynthesis and respiration is, and how much CO_2 is sequestered by the tree (in kg) to produce what amount of tree (in kg), and to calculate the carbon dioxide emission for the human. As we go through this power point the students are going to fill in some of the questions on the worksheet to help them keep track of major concepts.

Activity:
First, we will go over the power point, what a photosynthetic reaction is and what is respiration. The power point will explain how much carbon dioxide is sequestered by the tree (in kg) to produce certain amount of tree (in kg). As well, it will give the average calorie intake for humans and how much energy (in kg/day) is needed to release carbon dioxide into the atmosphere. Students will be given a worksheet with all the information and calculation. Students will be asked to calculate the volume, the weight of the tree and the carbon footprint of the tree from the data given to them. They will also calculate the amount of CO_2 (in kg) being released in both neighborhoods by humans per day and to figure out the average population of the specific areas that were measured using proportions based on the Total Population Density for the whole neighborhood. As well, students will be asked to figure out how much CO_2 is being emitted in that area using the data from the first sheet.

Assessment:
When there is about 5-10 minutes left in class, have the students present as much of the calculated data with the rest of the class and go over the calculation on the board.

GK-12 Brooklyn College: City As Lab

ITAVA Group: Fall 2011: 45 minutes

Scientific Methods

Objectives: Students will be able to:

- Understand the principle behind scientific methods
- Construct a hypothesis, perform an experiment and report their results

Materials:

- Hard boiled eggs and raw eggs

Procedure:

Aim: Being Able to Form a Hypothesis, Perform an Experiment and Report the Results.

Do Now: The class will be broken up into groups. Each group will receive 2 eggs. One is raw and the other is hard boiled. The eggs will be labeled A and B. Within the group, they will have to come up with a way to figure out if the egg is cooked or raw without breaking it open, and at the end they will test their predictions by cracking the eggs. Have the students practice by following the scientific methods; for example, have them develop a hypothesis, etc. Make sure you go over the scientific methods with them before they start the Do Now, and that they understand how to construct the hypothesis, how perform their experiments based on the hypothesis they formed, how to collect record and analyze their data and how to draw a conclusion.

Assessment:

After the students have gotten through the Do Now, have each group share their hypothesis and different ways they have performed their experiments, as well as their results. Discuss with them if their methods were reliable and consistent. At the end of the discussion, have each group bring their egg they think is hard boiled to the front, and test to see if their hypothesis is correct, by breaking it over the sink.

Scientific Method

Ask Question (state the problem)

↓

Background Check (gather info)

↓

Construct Hypothesis

↓

Test w/ experiment

↓

Record & Analyze Results & Data

Draw Conclusion

↙ ↘

Hyp. TRUE Hyp. FALSE

↘ ↙

Report Results (Repeat Results)

1. **Ask Question (state the problem)**
   -Scientific method starts by asking a question about something you observe: How? What? When? Who? Which? Why? Or Where?
   -in order for scientific method to answer the question it must be something that you can measure (ex w/ numbers)

2. **Background Check (gather info)**
   -rather than starting from scratch and putting together a plan to answer your question, you can use library and Internet research to help you find the best way to conduct your study and insure you don't repeat mistakes from the past.

3. **Construct Hypothesis**
   Educated guess about how things work
   -state hypothesis in a way that you can easily measure and in a way to help you answer your original question.

A good hypothesis meets several standards.

- It should provide an adequate explanation of the observed facts.
- If two or more hypotheses meet this standard, the simpler one is preferred.
- It should be able to **predict** new facts.

4. **Test Hypothesis by Doing Experiment**
   -your experiment tests weather your hypothesis is True or False
   -experiment has to be fair test
   -Conduct a fair test by making sure that you change only one factor at a time while keeping all other conditions the same
   - repeat your experiment several times making sure the first results weren't just an accident

Key Elements of the Experimental Procedure

- Description and size of all experimental and control groups.
- A step-by-step list of everything you must do to perform your experiment. Think about all the steps that you will need to go through to complete your experiment, and record exactly what will need to be done in each step.
- The experimental procedure must tell how you will change your one and only independent variable and how you will measure that change
- The experimental procedure must explain how you will measure the resulting change in the dependent variable or variables
- If applicable, the experimental procedure should explain how the controlled variables will be maintained at a constant value
- The experimental procedure should specify how many times you intend to repeat your experiment, so that you can verify that your results are reproducible.
- A good experimental procedure enables someone else to duplicate your experiment exactly!

Preparation

- **Know what to do.** Read and understand your experimental procedure. Are all of the necessary steps written down? Do you have any questions about how to do any of the steps?
- **Get a laboratory notebook** for taking notes and collecting data.
- **Be prepared**. Collect and organize all materials, supplies and equipment you will need to do the experiment. Do you have all of the materials you need? Are they handy and within reach of your workspace?
- **Think ahead about safety!** Are there any safety precautions you should take? Will you need adult supervision? Will you need to wear gloves or protective eye gear? Do you have long hair that needs to be pulled back out of your face? Will you need to be near a fire extinguisher?

5. **Record Data & Draw Conclusion**
   -once your experiment is completed and all the data collected, you analyze your data, measurements to see if your hypothesis is true or false
   -scientists often find that their hypothesis is false and construct new hypothesis
   -start the entire e4xperiment all over again

6. **Report Results**
   -communicate your results to others in a final report (ex poster, publication)

   Your final report should include the following:
   -Title page.
   -Abstract. An abstract is an abbreviation version of your final report.
   -Table of contents.
   -Question, variables and hypothesis.
   -Background research. This is the research paper you write before you started your experiment.
   -Materials list.
   -Experimental procedure.
   -Data analysis and discussion. This section is the summery of what you found out in your experiment, focusing on your observations, data tables, and graph(s), which should be included in the discussion.
   -Conclusion.
   -Ideas for future research
   -Acknowledgements. This is your opportunity to thank anyone who helped you with your science fair project, from a single individual to a company or government agency.
   -Bibliography.

GK-12 Brooklyn College: City as Lab
ITAVA Group: Spring 2012: 45 minutes

How to Write an Abstract for a Science Poster?

Objectives: Students will be able to…

- Write an abstract for a science poster

Materials:

- Accompanying power point
- Science posters

Procedure:

Aim: How to Write an Abstract For a Science Poster?

Lesson:
The power point presentation will go through the basics of what a good abstract for a science poster should include. As well, the power point will give examples of different abstracts for a science poster.

Activity:
First, we will go over the power point, what a makes a good abstract for a science poster and a list of items that should be included. The power point will also include example of good abstract for a posters. As we go along the power point, the student will make notes of the most important things. When finished, the students will be divided in three groups to come up with the abstract for their own poster based on the project they were working on.

Assessment:
When there is about 5-10 minutes left in class, have the students present the abstract they have written to the rest of the class. Have the rest of the class give them feedback and comments.