BIO-RECLAMATION AS A DEFENDER AGAINST ACID MINE DRAINAGE AND RELATED ENVIRONMENTAL ISSUES IN ABANDONED COAL MINES OF WEST BENGAL

DR. SHARMISTHA MUKHERJEE

Assistant Professor

ACHHRURAM MEMORIAL COLLEGE, JHALDA, PURULIYA

Email ID mukherjee.ruh23@Gmail.Com

INTRODUCTION

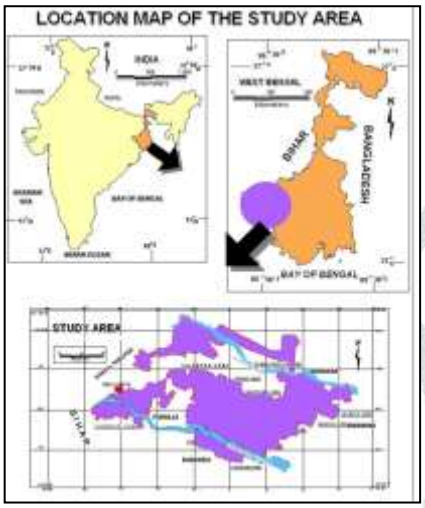
On Feb 28, 2007, an explosion in an abandoned underground coalmine tore through several homes in West Bengal's Burdwan district causing cracks along a stretch of the NH2 (that connects Kolkata to Delhi), disrupting road and railway traffic in the area. The blasts happened in a coalmine near Asansol. Preliminary investigations found that the cracks along the highway developed due to subsidence in the area where an abandoned coalmine is located. Officials of the directorate general of mines safety, say, the explosion was probably caused by methane, a coal-bed gas, which had accumulated in the abandoned pit. The blast, in turn, collapsed underground pillars in the mines and caused the subsidence. The mine, owned by Eastern Coalfields Limited (ECL), was abandoned in the 1960s but was not filled up with sand (a precautionary measure against subsidence). The pit was sealed in 2005 after a baby fell into it. ECL has refused to take responsibility for the abandoned mines and blamed illegal mining for the incident.

Fig 1 Abandoned Mine Of Raniganj

The above report proves that one of the major outstanding environmental problems related to mining is that of abandoned mine sites, a legacy of centuries old practices, of inadequate, insufficient or non-existent mine closure. The potential costs of rehabilitation, the lack of clearly assigned or assumed responsibility, the absence of criteria and standards of rehabilitation as well as other factors have delayed action by all parties – industry, governments and communities. Yet, land degradation from old mine operations is well known in almost all countries. While many have seen these derelict sites, and there are many references in the literature, there have been few systematic surveys to quantify how many sites need attention. There has been even less work to quantify the nature of associated problems so as to priorize remediation efforts. UNEP has begun to collect information using national or regional inventories in addition to a global survey on this. Whenever coal is mined underground a void is left by the mining process. It can either be supported and left open, partially filled (backfilling or stowing) or allowed to collapse behind the active working face. It is the latter that is the prime cause of subsidence, for as the immediate roof rock directly above the mine opening collapses into the mine void, the subsequent layers of rocks above the mine will sag or lower until this ground movement reaches the surface. This surface deformation or lowering is called mining subsidence. It occurs mainly during and in the months immediately after coal extraction (active mine subsidence) or some portion of it can occur many years later (abandoned mine subsidence). Sometimes the later occurs when the support left in the mine deteriorates and fails, again allowing roof rock to collapse

and triggering another more local subsidence process. Abandoned mines are dangerous and should not be visited in the field. The abandoned mine inventory is not intended to encourage or facilitate people to visit these sites in the field. This is particularly important due to hazards that can be present. Most of the sites are on private land and access without permission would constitute illegal trespassing. It is also important to recognize that abandoned mines can have negative impacts outside of the boundaries of the site where mining activities took place. For example, eroding tailings and/or contaminated water can be present and have toxic effects downstream (down gradient) from the site where mining, mineral processing and waste disposal occurred. At the end of its life, a mine has the potential to leave a legacy, either positive or negative. History has shown that in most cases the legacy left has been negative due to the following:

• Human health risk – contaminants from poorly maintained mines, tailing dams and tailings



• Safety risks – open holes (pits and shafts), collapsing tailings, impoundments, machinery and machinery parts

• Environmental risks – contaminated soil and water, loss of biodiversity

• Socio-economic impacts – communities left without livelihoods

• Political risks – where a country or state may be open to accusations of breaching international environmental legislation

• Reputational risks – in particular for companies as a whole and leading to potential restrictions on their license to operate

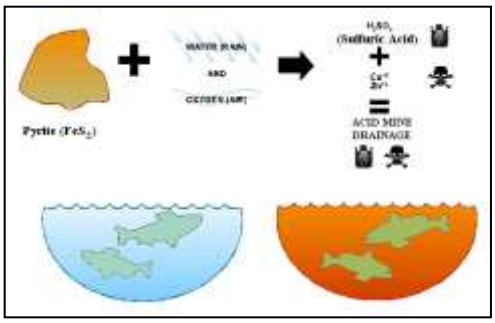
Fig 2 Location Map Of The Study Area

PRESENT ALLOCATION OF ABANDONED COAL MINES IN WEST BENGAL

Over the last 100 years, mining has helped build and expand communities across Raniganj and continues to play a significant role in the economic well-being of many communities; Mining currently contributes over $2 billion annually in mineral production to the provincial economy. Today's mining practices and regulations ensure that mines are operated and closed in an environmentally sound manner; however, many communities across West Bengal, including Raniganj, are dealing with the legacy of mines that were abandoned decades ago and continue to pose health and safety problems.

In 2000, ECL established the Orphaned/Abandoned Mine Site Rehabilitation Program to address the public safety and environmental health concerns associated with orphaned/abandoned mine sites. Under the program, 149 former mine sites were identified as orphaned or abandoned (O/A), which include five high-priority sites, 31 high-hazard sites and the remaining low- to moderate-risk sites. All sites have been inspected for safety and environmental hazards, prioritized for rehabilitation and have had long-term rehabilitation plans developed. Between 2002 and 2005, a major cleanup of the site was done to mitigate safety hazards, including demolition of mine structures, shaft capping and fencing. A Human Health and Environmental Risk Assessment was completed identifying additional demolition, clean-up and tailing remediation to be undertaken. On 21 Aug 2010 West Bengal State Government has proposed to take over 27 coal mines that have been abandoned by Eastern Coalfields Ltd (ECL) and operate them on a public-private partnership (PPP) basis.

ENVIRONMENTAL PROBLEMS GENERATED BY ABANDONMENT OF THE COAL MINES



Acid mine drainage is polluted water discharged from usually abandoned mines. When the ores exposed to air and water react to form a sulfuric acid solution containing dissolved metals. This mixture is known as acid mine drainage. Raniganj coalfield is also suffering from this problem. Raniganj coalfield has a long and proud history of mining, which has been responsible for much of both the economic and the social growth and development of the country.

Fig 3 Formation Of Acid Mine Drainage

However, historically the focus of the owners of those mines, as well as the legislation itself, has been on removing the mineral commodities from the ground at a profit, and not on the rehabilitation of the mine features once mining had ceased. Although much money was garnered from mining companies and individuals through taxation, none of this was set aside for assuring mine site rehabilitation. The impact of abandoned sites is significant including:

1. Altered landscape due to unused pits and shafts alongwith risks of falls into shafts and pits;
2. Land no longer useable due to loss of soil, ph and lowers ph, between 2.0 and 3.0
3. Abandoned tailings dumps;
4. Changes, losses in groundwater regime, contaminated soils and aquatic sediments;
5. Frequent subsidence and rear landslides.
6. Changes in vegetation and loss of productive land;
7. Pollution of surface water by sediment or salts, fish affected by contaminated sediments and changes in river regimes; Alters phosphorus availability.
8. Air pollution from dust or toxic gases; Reduces buffering capacity

In addition to the obvious problems for the community, most of these situations present a considerable cost to the public authorities who are often expected to make the sites secure and prevent ongoing pollution. The public is increasingly demanding action and this visible legacy of the past is producing a growing community opposition to mining activities generally.

BIO-RECLAMATION TECHNIQUES TO COMBAT RAPID DESTRUCTION OF THE LANDSCAPE

According to Coal India Limited legislation, Abandoned Mine/Orphaned Mine means a mine where the legal owner is known but unable or unwilling to take action or a mine where the owner cannot be traced / identified. Much less attention is given to the impact of mines once they have ceased operation, particularly those which are not closed in line with today's standards. The resulting abandoned mine and mining communities provide memories of times past, leaving a scar on the local environment. Globally, countries have put in place a range of programs and policies, very often complemented by company policies, to ensure that once a mine ends it is properly rehabilitated.

While many mine operators have taken precautions to fill in and secure abandoned mine areas, many old mines were opened and then abandoned long before any consideration was given for making the areas safe after ore extraction was completed. There are very limited records of the locations of shafts. Also it may not be known how near the surface these undermined areas are or how extensive the mine voids may be. People enter abandoned mines for a variety of reasons, ranging from curiosity to vandalism. Those who seek these pastimes often meet with sorrow and misfortune. Many young people (as well as adults) have been killed or injured while attempting to satisfy a desire to explore old mines, caves, and open pits. In some cases a fire may occur in an abandoned mine. There may be no ventilation, odorless explosive or

flammable gas may be present. Even if that is not the case, a fire could deplete limited oxygen, liberate dangerous gases and spread through the mine, cutting off any escape. It may also be a perception that abandoned mines are all part of history, but mines continue to be abandoned for a range of reasons. If insufficient funds are set aside for financial assurance then there are no resources for rehabilitation once the sites revert to government hands. Those older sites with little or no financial assurance create greater challenges for management.

For reclaiming the mining sites biologically there are increasing biological techniques through the development of specific equipment, products, methods of hydraulic seeding and vegetation restoration to establish vegetation on degraded lands or by applying a substantial vegetative cover to many rehabilitated opencast mines to prevent erosion and restore the area's vegetation to its natural state that has helped pioneer the landscape, soil reclamation and erosion control industry through its years of experience on projects in many parts of the country. Hydroseeding technique is the main method of sowing seed which involves a sophisticated mechanized process that is used for the application of seed to establish vegetation on rehabilitated opencast mines. An all-in-one mixture of specific and selected grass seeds, fertilizers, combined with a soil binder or tackifier (resinous material), blended mulch, soil ameliorants (lime or gypsum) , growth stimulants and water, is applied onto the prepared surfaces at a predetermined application rate. Seed germination is enabled by a microclimate that is created by a fiber layer, which is formed by the soil binder or tackifier when combined with the blended mulch. This encourages the young root systems of young emerging vegetation to develop quickly, anchoring the outer layer of the soil, which significantly reduces erosion and accelerates the plant succession of the applied vegetation types. The hydroseeding process involves the use of highly specialized hydraulic seeding equipment with a built-in agitation system and a specialized centrifugal pump for handling varying viscous slurry formulations. Specialized trucks are deployed to access almost any type of slope or terrain and the centrifugal pump allows a spraying distance of over 60 m. Another advantage of using hydroseeding is that it is one of the cheapest methods to apply a vegetative cover and provides the control to cover difficult, inaccessible areas, such as slopes to adapt the applications and product selection to the requirements of the site, a full on-site evaluation is necessary. A soil analysis determines the exact soil improvement material requirements. Vegetation planted on old opencast mine sites will vary according to the location and local endemic vegetation. A mixture of commercially available annual and perennial veld grass species is applied in order to attain succession of the grass types. Some challenges in the industry include the chemical amelioration of the *in situ* soil (a cleanup or remediation of a polluted site to use and simulate the natural processes in the soil) as the pH of the soil is often low. It is often necessary to chemically alter the soil profile to attain a long-term vegetative cover.

Besides digging up vacant plots, private miners extract coal from mines abandoned by ECL or even by private companies that were dug before the nationalization of collieries. Because of poor mining techniques, excavation makes the surface unstable; cracks appear and widen with the underground combustion of methane gas trapped in coal beds.

These positive externalities have included:

- Reduced impacts through the removal of hazards such as open pits, contaminated water and potential earth and soil movement;
- Contributions to community throughout the operation of the mine – employment, training, investment in sporting and community groups; infrastructure; targeted employment of indigenous populations, women etc;
- Increased economic benefit to the local community and broader region through tourism and/or other industry moving into the area;
- Improved community facilities and environment – parklands and native ecosystems established on mine landforms;
- Improved environmental outcomes where work around the mine site has facilitated broader environmental work within the region;
- Energy supplies and other infrastructure which remain after mining ceases; and
- mining heritage tourism for new economies

- Enabled vegetation establishment
- Effect was spatially variable creating an aesthetically-pleasing landform
- Treatment with dried pelleted sewage sludge, limestone and peat and application of *Typha sp.* (cattails), *Sphagnum*, Green algaes, *Chlamydomonas aplanata*) Blue-green algaes, *Spirulina nordstedtii* (4.9) Diatoms, *Navicula nivalis* (3.0). After which trees were planted *Betula pubescens* and *Alnus glutinosa* (common alder), Mushroom compost substrate, Cattails (Typha latifolia).

- Construction of settling pond and surface flow wetland to receive spoil drainage.

Fig 4 Constructed wetlands as treatment systems

The responsibility for treating acid mine drainage is the crucial issue. As it was not foreseen, when the pumping of mines began, that there would be a problem of acid mine drainage there was nothing set aside to deal with the financial implications. There was also little concern in the early 19th century about potential environmental problems which might result from industrial activity. Often the companies responsible for the sinking of shafts into the ground are no longer in operation and the problem has not materialized because of the continued pumping by other mine operators in the near vicinity. The question is whether the last operator to stop mining and switch off the pumps should be held responsible for the drainage. It is only then that the problem is noticed though the activity responsible for the drainage will have been carried out by all of the mine operators within the same catchment area. It was argued in a court case in 1993 that Section 89(3) of the Water Resources Act (WRA) 1991 allows that pollution events which are caused only through "permitting" water from an abandoned mine to enter controlled water are not considered an offence under section 85 of the same Act. The subsequent judgment highlighted a loophole in the law which allowed pollution to occur and no-one to be held responsible. The loophole will be removed as of the 31st of December 1999 (through section 60 of the Environment Act 1995), but this foreknowledge may be responsible for mines closing in advance of liability being taken on by mine operators. So it is needed only consciousness and probable mitigation techniques to lower it down.

ACKNOWLEDGEMENT

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