PROBLEMS OF GROUND WATER IN CONNECTION WITH ABANDONED OPEN PIT MINES

Amarasooriya A.M.S.B, De Silva M.R, Suraweera P.C.T.K., Wedage W.N
**Karunarathne S, Disanayake D.M.D.O.K*

Department of Earth Resources Engineering, University of Moratuwa, Moratuwa
**Corresponding Author email: shiromi@earth.mrt.ac.lk*

ABSTRACT

Mining is an essential activity upon which many other industries rely on immensely. The magnitude of the problem caused by abandoned mines in the time to come can be understood from the topographic maps prepared using remote sensing applications and field studies in Athurugiriya, Gonapola and Kaduwela areas of the Colombo district. Mahara harbour quarry and the Ragama prison quarry, two abandoned metal quarries were studied with reference to the prevailing conditions of the water quality and the ground water regime. Geological investigations were conducted at the site to identify possible linkages of the pit with the surrounding ground water regime. By analysing the water samples for physical, chemical and biological parameters, the quality of the water was studied .Results show severe pollution in pit water as well as in surrounding ground water. The harbour quarry has maintained it's purity due to the efforts and care taken by its stakeholders and neighbours. The continuously degrading quality of the environment at the prison quarry site makes its neighbours affected as well as accused for the problem. The study further shows that in addition to the water quality studies, socio environmental factors should be further studied in order to provide a sustainable solution to the prevailing environmental pollution problems related to abandoned open pit mines in and around Colombo district.

KEY WORDS

Abandoned mines, Environmental impact, Open-pit, Reclamation, Water Quality

INTRODUCTION

The imbalance in the natural eco system brought about by mining is often compensated to the fullest possible status by sustainable mining operations. The guidelines provided to the mine operators along with the licenses regarding mine rehabilitation and reclamation lacks instructions and guidelines for short term and premature closure of mines. This leads the mining area out of proper care and supervision leading to intense adverse polluted conditions.

Degradation of water quality and ground water pollution is not the only and most prominent adverse after-effect of mining. A pit, which traps runoff water, provides favourable conditions for breeding and spreading pollution and contaminants. Such abandoned Pits are often used as waste disposal sites by the neighbours. Often, the refilling medium introduces contaminants to the stagnating water. Also abandoned excavated rocks due to the mining activities undergo decomposition and enrich the stagnating waters with complex and persistent pollutants. As a result these abandoned mine pits are converted into breeding grounds for disease causing organisms and become an environmental threat over the time.

More often the neighbours living near the mines oppose the mine operations, largely due to the fact that the basic concepts of sustainable development are not put in to practice.

Usually a pit holding a considerable amount of polluted water opposes a threat to the adjoining ground water regime or the aquifer. Normally the soil is permeable though the rocks are not. By studying the in-situ intact rock of the area and the rock outcrops the presence of a weak structure of the rock can be predicted. The main objectives of the study are;

(i) Identification and mapping of open cast mines and abandoned mine pits in and around Colombo district.

(ii) Assessing the water quality and the environmental impact opposed by a selected abandoned quarry at Mahara-Ragama.

(iii) Proposing a suitable rehabilitation method for the investigated Mahara Ragama prison Quarry.

MATERIALS AND METHODS

Using Google Earth web application and other remote-sensing data, most of the open-cast mines and pits in Colombo district were identified. Those identified locations were visited in the Gonapola, Kaduwela and Athurugiriya areas. The GPS coordinates of the pits; mines and the pH (Hannah pH meter) of the pit water were recorded. A data layer for a 1:50,000 topographic maps were prepared using this data. Out of these the Boralasgamuwa Clay mine, Naligama Harbor Quarry and the Prison Quarry were selected for further investigation of the present situation. The prison quarry was selected for a further detail study. The pit covered an area of 50752m^2 and an average depth of 3.108m. It was situated amidst of a densely populated newly built housing scheme occupying by about 135 families and many other low income holder families. The study was conducted in August-September 2006. About 75 dug wells surrounding the pit were subjected to water quality analysis for basic parameters with The intention of identifying the changes of ground water quality around the pit boundary. Among them ten wells and the pit as shown in Fig 1 were selected and further detailed analysis was conducted. Sample collection, preservation and analysis elaborate ASTM standards. Following parameters were measured to asses water quality of the pit and surrounding ground water. pH(Hannah meter),turbidity(Turb 350 IR),Dissolved oxygen (HI 9142 DO meter), Conductivity/salinity meter. Open reflux titration method for COD, UV spectroscopy method for NO_2^-, NO_3^-, PO_4^{3-} and Total Solids, ASTM, EDTA titration method for hardness, atomic absorption spectrometer for heavy metal (Fe,Cd,Cr,Pb) and Nessler method for NH_3 determination were used. By analyzing the water samples for physical, chemical and biological parameters, the quality of the water was studied. The area was geologically investigated and the salient features were mapped. The socio economic aspects of the people were also investigated during the preliminary study visit to understand the human factor in the pollution state of the mine.

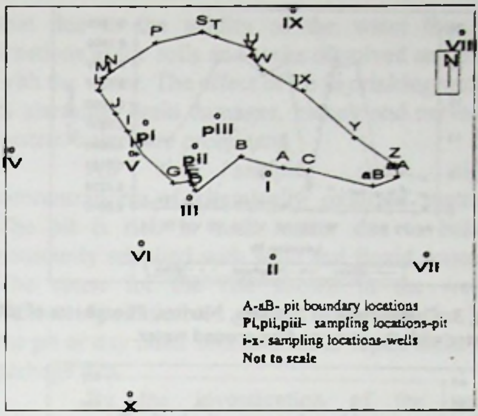

Fig 1. Sampling locations of the Prison Quarry

The wells I-III were located in the same ground elevation of the pit in the refilled area, while all the others were located at higher elevations.

RESULTS

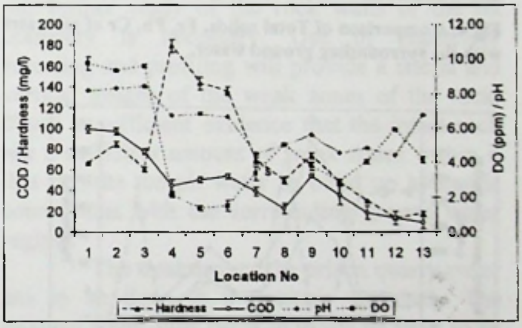

Fig 2: Comparison of COD, Hardness, DO and pH of pit water with the surrounding ground water.

The lowering of the pH is more distinct from well IV to IX Except for well V and IX all the other wells fall below drinking water standard of 8mg/l DO. Undesirable levels of hardness are observed at wells I, II, III which were located in the refilled medium.

Wells IV-VII also indicates a small presence of ions while the pit waters show surprisingly low figures. Wells I-III show elevated amounts of solids as well as high amounts of hardness as Calcium and lowered amounts of DO. A motor was used for pumping at well III and its effect is notable where the amount of solids and turbidity rises without a distinct rise in conductivity and salinity.

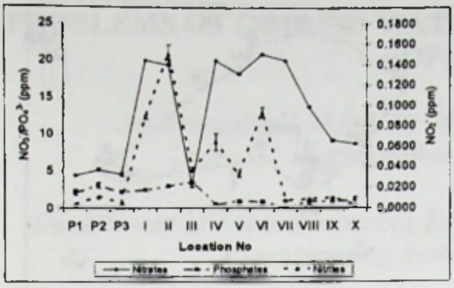

Fig 3: Comparison of Nitrates, Nitrites, Phosphates of pit water with the surrounding ground water.

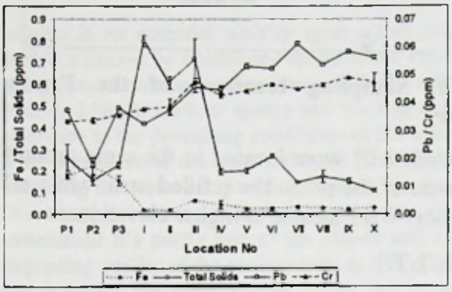

Fig 4: Comparison of Total solids, Fe, Pb, Cr of pit water with the surrounding ground water.

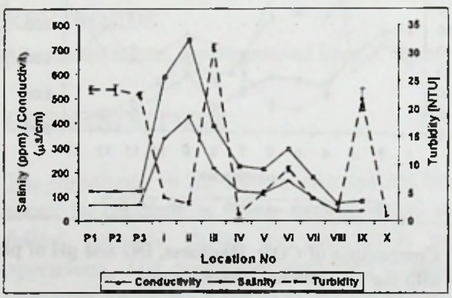

Fig 5: Comparison of Conductivity, Salinity, Turbidity of pit water with the surrounding ground water.

DISCUSSION

The wells I-III seems to be affected by seepage from the pit. when the distance the pit to the wells are more, the acid buffering capacity of the pit and its surrounding soils and rocks are high. The wells in the refilled area show anomalously high conductivity and salinity which indicates the presence of large amounts of dissolved ions. Even though the pits receive large amounts of ions they are easily diluted with the high volume of water. Due to high phosphate levels cause for raising of algae levels tend to eutrofication.

The pit is often mixed by winds while the wells are not so. The amount of DO varies with the depth of the wells and deep wells show false values of DO due to the water sample being transported over a long distance.

Elevated nitrate levels suggest the possible presence of other contaminants such as disease-causing organisms, pesticides, or other inorganic and organic compounds that could cause health problems Nitrate reactions [NO_3^-] in fresh water can cause oxygen depletion which is indicated as a depletion of dissolved oxygen as observed in the wells. The major routes of entry of nitrogen into water body are wastewater, septic tanks and discharge of solid wastes. The results suggest that the wells are contaminated with septic wastes more than other causes. The lowering of nitrates in the pit and in well III can not be concluded as desirable since it may be due to being utilized by bacteria in the water.

The wells show a similar but subtle pattern which raises doubts about bacterial actions of the wells but the utilization of NO_3^- by such species seems low. On the other hand nitrification bacteria in the soil profile effects the ground water to enrich from NO_2^-.

When excessive amounts of phosphorus and nitrates are present in the water, algae and aquatic plants will thrive in large quantities. When these algae die, bacteria decompose them, and use up oxygen. This process is called eutrophication. Dissolved oxygen concentrations can be lowered due to this excess population of bacterial species. The pit and the wells in the refilled soil show striking amounts of PO_4^{3-} and indicates a link between the pit and the ground water profile of the area. The other wells were not within permissible levels either.

According to the people in the area during the dry season some wells turn in to yellow color and produce an irritating odor. This may be due to the fact that as water evaporates the concentration of NO_2^- and PO_4^{3-} rises and the water reach eutrophication quickly resulting in excessive algal and bacterial activities. Anaerobic conditions cause bad smell and yellow color.

The pit is certainly polluted with septic water and sewage lines directly discharging to it. Since the houses have not been provided with a suitable septic drainage system the residents have dug their own septic tanks and wells within undesirable short distances as low as 2-3m between them. The state of contamination by sewage is yet to be confirmed.

Rainfall can cause varying amounts of phosphates to wash from lands into nearby waterways and in to the pit. The rapid growth of aquatic vegetation can cause the death and decay of vegetation and aquatic life because of the decrease in dissolved oxygen levels. Phosphates are not toxic to people or animals unless they are present in very high levels. Digestive problems could occur from extremely high levels of phosphate.

Total solids relates to turbidity, except that it includes not just suspended solids, but also dissolved solids such as the mineral ions calcium, phosphorus, iron, sulfur and bicarbonate. A certain level of these ions is essential for life. However, too much dissolved solids in water can affect humans by inducing a laxative effect and giving the water a mineral taste. Increased total solids has a similar effect to turbidity in that water clarity is reduced, water temperature can rise, oxygen levels can fall as a result of less photosynthesis, and solids can bind to toxic compounds and heavy metals.

All the samples show undesired levels of solids except in that of well X which is also in the margin. The anomaly of the wells I, II and III might be due to being in the refilled soil cover and in the vicinity of the pit...

Undoubtedly the pit showed high possibility of being polluted by solid wastes, waste water flows and septic discharges. Well IX is an extreme deep dug well with no properly constructed well walls or a collar. This results in a constant addition of silt and soils to the sampling bucket. The water from the well III was pumped to an overhead tank using a centrifugal motor and samples were collected from water flowing via the pipe lines. The causes for anomalies must have been due to this pumping.
Elevated levels of hardness in wells I-III suggest that that soil profile introduces an artificial hardness to those wells.

The pit shows abnormally high amount of Fe which can be suspected to origin from decaying iron that lay at the pit bed. Iron in domestic water supply systems stains laundry and porcelain. It appears to be more of a nuisance than a potential health hazard. Excessive amount of Cr is not presented in any location. An anomalous high content of Pb could be seen in the wells from V to X. It's possible that due to the acidity of the water the Pb fractions in the soils and rocks dissolved and mix with the water. The effect of Pb in drinking water is alarming; brain damages, kidney and nervous system failure are prominent.

All the samples show high concentrations of chemically oxidized matter. The pit is rich in such matter due to being constantly supplied with solid and liquid wastes. The cause for the rise shown in the wells indicates pollution of ground water aquifer by the pit or any other source such as septic tanks or garbage pits.

By the investigation of the rock outcrops of the surrounding area it can be found that the bed rock lies on the $080^0/53^0$W. Three major joints of approximately $140^0/16^0$E can be found on the exposed rock face of the pit boundary wall. A fault dipping 90^0 can be seen on most of the out crops. There is evidence that a series of fault planes lay parallel to this mainly visible fault plane as well. When dewatering the pit, further study of the rock walls of the pit boundary is necessary. Use of resistively sounding and profiling will provide a lateral and vertical insight of the weak zones of the rock. There is sufficient evidence that the intact rock has a sufficient amount of weak zones within it that permits the pit water to build up hydraulic connections with the surrounding ground water regime.

The treatment of the prison quarry water has to be done in a strategic approach. The inbound water flow paths in to the pit have to be barricaded and the sources of pollution should be separately treated. The pit has to be dewatered and the water should be passed through suitable treatment facility such as a sand bed filter, charcoal bed or a constructed wetland. Dredging of the sediments is essential.

CONCLUSION

The prison quarry indicates considerable levels of eutrofication as well as being contaminated by sewage. There is clearly evidence that the pit is responsible for the ground water contamination of area. The unavailability of proper sanitary facilities has made the situation even worst. Currently the water cannot be recommended for any normal application. The pit has the capacity to be treated in a systematical manner. Upon which it may be of high value of the neighboring residents and industries. Not all open pit mines and pits are alike. The mapping of Colombo district quarries and mines shows the immerging problems in its actual magnitude. In the processes of achieving sustainable development in the mining industry a map of all mines, pits, quarries and abandoned mines should be prepared for all the districts of Sri Lanka. Appropriate actions are necessary to understand the rising situation and act according to the prevailing conditions in a proactive manner.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to Mr. S. Weerawarnakula the former director of GSMB and Mr.Mudunkotuwa, the present director of GSMB for their kind corporation and generosity. All the guidance and support of Mrs. Y.P.S.Siriwardhane, chief chemist of GSMB is highly acknowledged.

The assistance provided by Mr. H.S Waidyasekara., Ms. Dilani de Seram, and Mr. D.N Kalutharage is highly appreciated. Special thanks extend to the residents of the Mahara Galwalawaththa and all the colleagues who gave their fullest support from the start of the study. This project was funded through a short-term research grant awarded by the University of Moratuwa.

REFERENCES

Arnold E., Lenore S., Andrew D., Standard methods for the Examination of Water and Wastewater-- 18^{th} edition 1992

Portable water, part 1-physical and chemical requirements, Sri Lanka Standards Institution

www,toxic.usgs.gov/sites[Accessed 2006-07-07] http://bcn.boulder.co.us

www.thebritishmuseum.ac.lk [Accessed 2006-07-07]

www.hgcine.com [Accessed 2006-07-07]