MECHANIZED GEM MINING IN SRI LANKA AND ITS EFFECT ON THE ENVIRONMENT

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Abstract :

Any form of mining of minerals has an adverse effect on the environment and gem mining is no exception. In Sri Lanka, gemstones have been mined for many centuries by traditional methods. However during the recent past, attempts have been made to mechanize gem mining. The mechanization can have far greater effects on the environment than traditional methods. The loss of employment opportunities in gem mining areas and the exhaustion of gem deposits in a shorter period are some of the other problems caused by mechanization.

1.0 Introduction

For many centuries, gems have been mined in Sri Lanka by traditional methods. The different methods are employed depending on the type and the depth of the gem deposit. As the depth of gem deposits increases, water pumps and winches have been introduced in place of manual lifting of water, clay and sand. Mechanization of this nature is essential to overcome problems which cannot be dealt with by traditional methods.

During the recent times, attempts have been made to introduce mechanized mining methods in Sri Lanka. However the mechanization is restricted by the loss of employment opportunities for people in mining areas and the environmental degradation associated with such mechanization.

2.0 Exploration

Since ancient times, gem prospectors are guided by village hearsay, past mining records in the area as well as their own practical experience in locating gem bearing gravel bed (Illama). Although, scientific methods of exploration have been employed to locate the existence of potential gem bearing areas, no follow up action has been taken to exploit them (Weerawarnakula, 1990). Most of these activities have been concentrated in locating in-situ gem deposits. During the recent past, in-situ gem deposits have been discovered by sheer accident. Corundum and spinel at Hatarabage (Weerawarnakula, Dharmaratne, 1988), Moonstone at Imbulpe (Harder, 1992), Corundum, Spinel and Tourmaline geods at Getahatta (Kumaratilake & Ranasinghe, 1992), Hessonite garnet at Kataragama (Weerawarnakula, 1991) are some of the examples.

Once a probable area of a placer deposit is decided, an exact location for excavation is established by driving a long pointed steel rod into the ground. By this method, miners can approximately determine the depth of underlying clay and sand layers and illama. As the point of the rod passes through illama and enters the underlying decomposed bed rock (Malawa), on retrevial, clay from Malawa will be found adhering to its point. The gem bearing gravel bed is indicated by the feel of the presence of quartz pebbles or boulders. Furthermore, the surface of the steel rod near the point gets scratched due to the presence of quartz or corundum in the illama.

3.0 Mining Methods

The mining methods depend on the nature and the depth of gem deposit. Fig. 1 gives a summary of mining techniques. When gemstones are found in the primary source rocks they are called in-situ deposits. The primary source rocks subjected to weathering, and transported by streams over millions of years, give rise to alluvial or placer deposits. A typical section of an alluvial deposit is shown in Fig. 2.

3.1 Traditional gem mining methods

3.1.1. Hand mining

The gem bearing gravel bed occured on or near the surface is exploited by using mammoties, crowbars and bamboo baskets. Clay or clayey material shoveled into bamboo baskets are thrown upward to the waiting hands of another man at the pit head. Method of bailing of seepage water of the pit, depends on the rate of water flow. It could be done by hand operated buckets or water pumps. When the gem bearing gravel bed is reached, it is collected at the pit head, separately and washed in running water, with closely woven conical bamboo baskets. If there is a shortage of water, surface digging can be dry sieved after removing large boulders. Only the retained material need to be washed to remove dust and clay. With the correct techniques of washing, gemstones can be concentrated at the bottom of sieve.

3.1.2. Open pits

The gemstones are mined in weathered in-situ deposits in a few places in Sri Lanka. Corundum and other precious gemstones, were recovered at Hatarabage and Haldummulla a few years ago and at present moonstones are mined at Imbulpe and Meetiyagoda from weathered in-situ gem deposits.

When the gem bearing veins are wide and occur near the surface, they are mined by open pits (Fig. 3). However the depth of the pit is governed by the value of gemstones recovered against the cost of removing waste material. If the veins are thin and the pit becomes deeper, it is advantageous to turn into underground mining method using shafts and tunnels (Fig. 4). Corundum and other precious gems have been mined in weathered in-situ deposits haphazardly and not continued to deeper levels. Moonstones are mined by open pits in weathered in-situ rocks where pits are shallow and the work involved in recovery of gem bearing veins is entirely labour intensive. The recovery of diamond, emerald and many other gemstones from insitu deposits in the world is carried out by systematic open pit operations using mechanical excavators, loaders and dump trucks. The mined out gem bearing rocks are processed by well designed plants.

3.1.3. Shafts and tunnels

The placer deposits and in-situ deposits occurring below a certain depth are mined by sinking shafts and excavating tunnels. In Sri Lanka, only placer deposits are mined by shafts and tunnels; as the deposit gets deeper, recovery of illama by successive pits become uneconomical. In such situations, it is a common practice to excavate tunnels at the level of gem bearing gravel to recover gemstones. The shafts are either round (2m diameter) or square (2m sides) in hard ground and small operations, whereas in soft ground like paddy fields they are rectangular (2 x 4 m), (Fig.4). The shaft is reinforced with timber rafters (rubber wood) while tree branches (ferns) are pushed between the sides of the shaft and vertical planks (arecanut tree) which are driven behind rafters to prevent the damp side walls caving in. When shafts are 3-4 m deep, clay and sand shoveled into small bamboo baskets are thrown upwards into the waiting arms of another man and so on until baskets reach the man on the shaft head. Deeper shafts utilize manually operated winches to lift excavated material and water. As the rate of flow of water increases traditional dewatering devices are replaced by water pumps.

The illama is collected separately near the shaft at specially prepared place where the ground is levelled and pressed. Thickness of the illama could vary from a few cms to a few meters and illama is always found on the weathered or unweathered base rock. The weathered base rock is known as Malawa while unweathered base rock is known as Parugala. The washing of illama is done in a near-by stream or a pond specially constructed for the purpose. The miners standing in the pond with water up to their waist and with baskets of illama, give circular motions to baskets to remove all the lighter materials. The washing is continued for about half an hour with illama being intermittently fed into the baskets. During the washing, lighter rocks that get collected at the top of the basket are hand sorted and thrown out of the pond and the heavy gems settle at the bottom of the basket. After washing, baskets are stacked over each other and an experienced miner collects gems while sweeping gravel back and forth with the hand.

When the illama is at a fairly deep level (10m) horizontal tunnels are excavated at the bottom of the shaft, so as to have the illama above the floor of the tunnel. The height of the tunnels are about 1-2 m and if the illama is thicker than 3-4 meters, further tunnels are excavated above the first one, keeping the roof of the first tunnels as the floor of the second one. If the illama dips at an angle, shafts are excavated inside the tunnel and new tunnels are excavated from such shafts. As the tunnels are excavated deep into the surrounding, fresh air for breathing as well as for lighting candles, becomes a problem, and in such situations pumps are installed to provide fresh air into the mine. The tunnels are supported with timber planks similar to shafts. In Sri Lanka, over 60-70 percent of mines are done by shafts and tunnels.

Deep in-situ gem deposits are mined by excavating shafts and tunnels in other countries. Diamond in South Africa, Sapphire in Montana, USA, are some examples.

3.1.4. Manual method of excavating river bed

When the placer deposits occur below a river bed at shallow depths, long-handled mammoties are used to scoop up the gravel. To prepare for this process, a brush dam is erected at a place where the river naturally slows down and water is allowed to escape from the side of the dam. Using long-handled mammoties, overlying sand and gravel are scooped over where water passes through. This procedure is continued until the illama is reached and it is loosened by using long pointed steel rods from the dam. The loose illama is also scooped over like before and moving water removes lighter and finer minerals leaving heavy gem minerals on the dam. Good gemstones can be easily seen and hand picked and the rest of the gravel is washed in the same manner as in the case of recovery of gems by shafts and tunnels.

3.2. Mechanized gem mining methods

3.2.1. Strip mining

Although strip mining is done in many countries in the world to extract placer deposits of coal, gem and bauxite etc, this type of mining method is not employed in Sri Lanka as yet.

The placer deposits and in-situ deposits can best be exploited by strip mining where the deposits are shallow and extend over a wider area (Fig. 5). In such situations small scale manual operations are most unsuitable. Overburden material in a placer deposit is removed along a strip and dumped on the side using draglines, bulldozers, loaders and heavy haulage trucks. The gem bearing gravel bed thus exposed, is either bulldozed or mined by draglines or long excavators and loaded onto trucks to be transported to processing plant. This material passes through a grizzly to separate out larger boulders and then through revolving trommel for initial breaking up. High pressure water jets are often used to wet the charge to facilitate the separation of particles from clay matrix. Oversized materials pass through the trommel to a reject stockpile or into trucks to be removed. Undersize fraction is then passed onto vibrating screens for further sizing by removal of fines. Coarse gravel from vibrating screens is fed to a jig where light minerals leave the jig or stays on the top and the heavy minerals get collected at the bottom which is separated at the end of each day's operation.

Strip mining can be used to expose mineralized pockets in the vein type in-situ deposits. The present method of haphazard open pit mining of these types of deposits yield poor results. What is required is to strip mine along the vein so that pockets of gem minerals can be exposed.

In strip mining, overburden from successive strips is placed back on the previously mined out area thus avoiding the need to transport material away and also filling the excavated area. The overburden piled aside, from the first strip can be dumped back on the strip excavated at very last, thus reclaiming the whole mining area.

3.2.2. Gravel pumps

The recovery of gems from river beds and some placer deposits have been mechanized by introducing gravel pumps to transport loosened illama to the surface. Slurry from the pump passes over a screen to remove boulders and tree remains etc and the small size gravel collected in a box below the screen, is further sorted out by washing with bamboo baskets.

Heavy gravel pumps are installed on the river bank and the screens and boxes are housed on a floating pontoon. The waste material is dumped back to the river. This process is very much faster than manual method. (Fig. 6).

The gravel pumps are used together with sluices and jigs in Thailand. In this instance, overburden is removed by bulldozers and gem bearing gravel is scraped into a hill. High pressure water cannon forces gravel into a gravel pump which carries them over sluices where heavy minerals get collected and lighter material pass over with the water flow. Most often, at the end of the sluice table, a jig is installed, so that the whole operation can be carried out faster. Jig is a machine where a pulsating movement is provided to the water, so that finer and lighter particles, flow over the top and heavy gems sink into the bottom. When a jig is in line, faster rate of flow over sluices can be maintained and it will carry some more gems to the jig while only large ones are left at the sluices. The recovery can be maximized by installing several jigs on line. At the end of the day, pumps are stopped and gems are collected from sluices and from a box at the bottom of the jig.

3.2.3. Dredging

A dredger is a floating vessel, consisting of a cutting head and suction pipe or bucket wheel and conveyor belt or bucket line, for the exploitation of the gravel bed (Fig.7). For the processing, screens and jigs are installed on the vessel. A dredger with cutting head is required if the material to be excavated is strongly bonded, but for loose placer deposits, bucket wheel conveyor is often sufficient. The excavated gravel from the suction pipe or bucket wheel conveyor is fed into a screen to remove rock boulders and the minus fraction is fed to a jig where gems get collected at the bottom. The dredging operation is a semi continuous one where machinery has to be stopped only for the collection of gems.

Finally every excavated matter except gems is dumped behind the dredger for restoration of the excavated area. However in river dredging, river banks will easily collapse under the suction and loose waste material will be carried away by the river flow.

4.0. The Environmental Effects

4.1. Social effects

Over several decades, gem mining has been done with or without valid permits from the government. The mining with permits requires the holder to deposit a certain sum of money with the government authorities to restore the land after mining. It is also required that public roads, waterways etc should not be damaged. However with illicit mining, pits are abandoned without refilling and waterways are damaged. Even in legal mining, it has been observed that lands are not restored and it is economical to forfeit the deposit than closure of pits. In both these ways, remote mining areas are left with pits which are ideal breeding grounds for mosquitoes, and malaria and dengue fever are very common in such areas.

If the area concerned is uninhabited, the effect will be mainly the soil erosion which could give rise to destruction of forests and silting of arable lands downstream. The destruction of forests could also lead to loss of rain etc.

Most often, miners lured by profitable illama tend to totally ignore the public properties such as public buildings, roads and waterways etc. Only after several years of mining, it is noticed that tunnels have been dug underneath public roads and waterways, when the roads subside or water diverts. The loss of visual amenity in a peaceful countryside due to unfilled pits is never considered important.

4.2. Economical effects

4.2.1. Positive effects

It is very clearly seen that the population in gem mining areas is not interested in state or private sector white collar jobs and several thousands of families are involved in gemming. Similarly there are many who are engaged in auxilliary services such as selling timber, fuel, groceries etc to miners.

It is further noticed that gem miners and gem dealers generously assist public institutions such as schools, hospitals and places of worship and charity organisations.

4.2.2. Negative effects

The mining of paddy, rubber and tea lands and subsequent abandonment of such lands with unfilled pits, directly affect the growers.

Furthermore due to both illicit and legal mining, silting of waterways is unavoidable. This forces the farmers to abandon their lands which have been cultivated for centuries, due to lack of water supply.

5.0. Discussion

It is a well known fact that any form of mining has an adverse effect on environment. It is a moral and obligatory duty of the mining enterprises to minimize the damage to the environment. Countries such as Australia and the United States of America have strict conservation laws on mining of gems and other minerals. However in Sri Lanka environmental laws are so mild that miners totally ignore them.

There have been, many instances in the past, when attempts were made to introduce mechanized gem mining methods in Sri Lanka. The use of gravel pumps in place of long-handled mammoties have been known for a few years now. Although it is a form of semi mechanization, its effect is not far greater than that due to the manual method. However the use of strip mining methods with excavators, loaders and washing plants etc could give rise to large craters unless excavated areas are filled up, but with almost no conservation laws to enforce restoration of lands, such mining could lead to environmental pollution of an unprecedented scale. Therefore attempts by local or international enterprises have so far not been successful.

Strip mining is advisable in lands which are likely to go under water in a reservoir or in in-situ gem deposits where large volume of rocks have to be excavated to find a pocket of gem mineralization.

Most recently, a project to dredge Kalu Ganga over about 50Km up to about 4m below the river bed from Kalutara upward was launched. However due to protests by environmentalists, the project has been suspended. It is note worthy that severe environment problems such as erosion of river bed and hence blockade of water from discharging into sea, collapse of riverbank which could result in floods, silting of agricultural lands down stream and inability to use water for household etc could result if such a project is permitted. This is obvious from the rate at which dredgers operate. A small bucket wheel dredger has a capacity over 200 m^3 per hour and it would only take a few months to exploit the length of 50 km. Therefore it is advisable to adopt the same principle for Kalu Ganga as in the case of small rivers where small lengths are auctioned in public and mining rights are given for a year. Such mining is carried out by manual method or gravel pumps and the rate of exploitation is very much lower than that of dredging. Therefore gem miners can continue to work on a small scale for over several decades for what could otherwise be extracted in a few months using dredging which also causes damage to the environment. With small scale operations, environmental damage can be well monitored and minimized.

6.0 References

1. Harder, H., 1992. Rauchmondsteine, eine neue Mondstein-Varietat, Z.Dt. Gemmol. Ges. 41,Nr.2, 69-85

2. Hughes, R.W., 1990. Corundum, Butterworth - Heinemann Ltd, 238-309

3. Kumaratilake, W.L.D.R.A., & Ranasinghe, U.N., 1992. Unusual Corumdum bearing gem packets at Avissawella and Gatahetta, Sri Lanka, Z.Dt. Gemmol, Ges. 41 Nr. 1, 7-17

4. Weerawarnakula, S., 1991. Personal Communication.

5. Weerawarnakula, S., Dharmaratne, P.G.R., 1988. Geological exploration for source rocks of gem minerals in Sri Lanka, Proceedings of the Seminar, "Mining and Minerals Engineering", University of Moratuwa, 01-13

6. Weerawarnakula, S., 1990. Could exploration for In-situ gem deposits change traditional gem mining methods in Sri Lanka? Proceedings, 2nd Asia Pacific mining conference, Jakartha, Indonesia, 218-223.

GEM MINERAL DEPOSIT

- Shallow (< 10m)
  - Surface mining
    - **Placer deposit**
      1. hand mining
      ii. open pits
      iii. strip mining
    - **In-situ deposit**
      1. strip mining
      ii. open pits
      iii. shafts
  - Underwater
    - **Placer /in-situ**
      1. Manual
      ii. Gravel pump
- Moderately deep
  - Surface mining
    - **Placer /in-situ**
      1. shafts & tunnels
  - Underwater
    - **Placer deposit**
      1. gravel pumps
      ii. Dredger
- Deep (> 20m)
  - Surface mining
    - **Placer/in-situ**
      1. shafts & tunnels

Fig. 1 - Summary of Gem mining methods

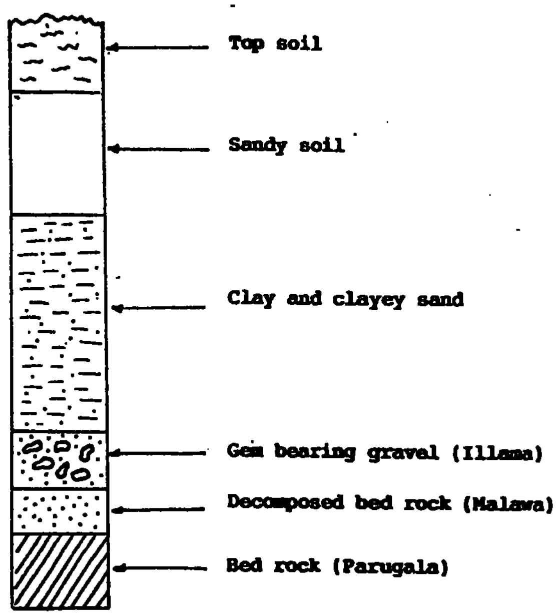

Fig: 2 - Generalized cross section of placer gem deposit

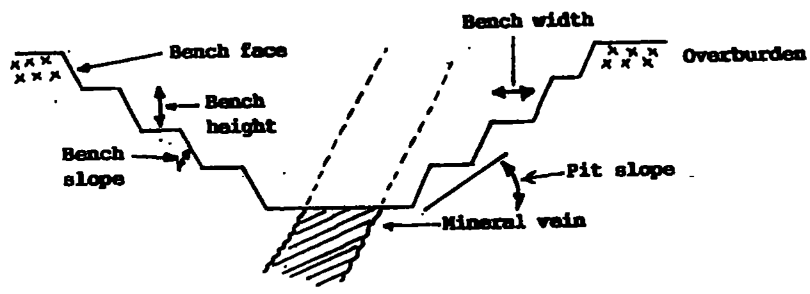

Fig: 3 - Open pit mine for in-situ deposit

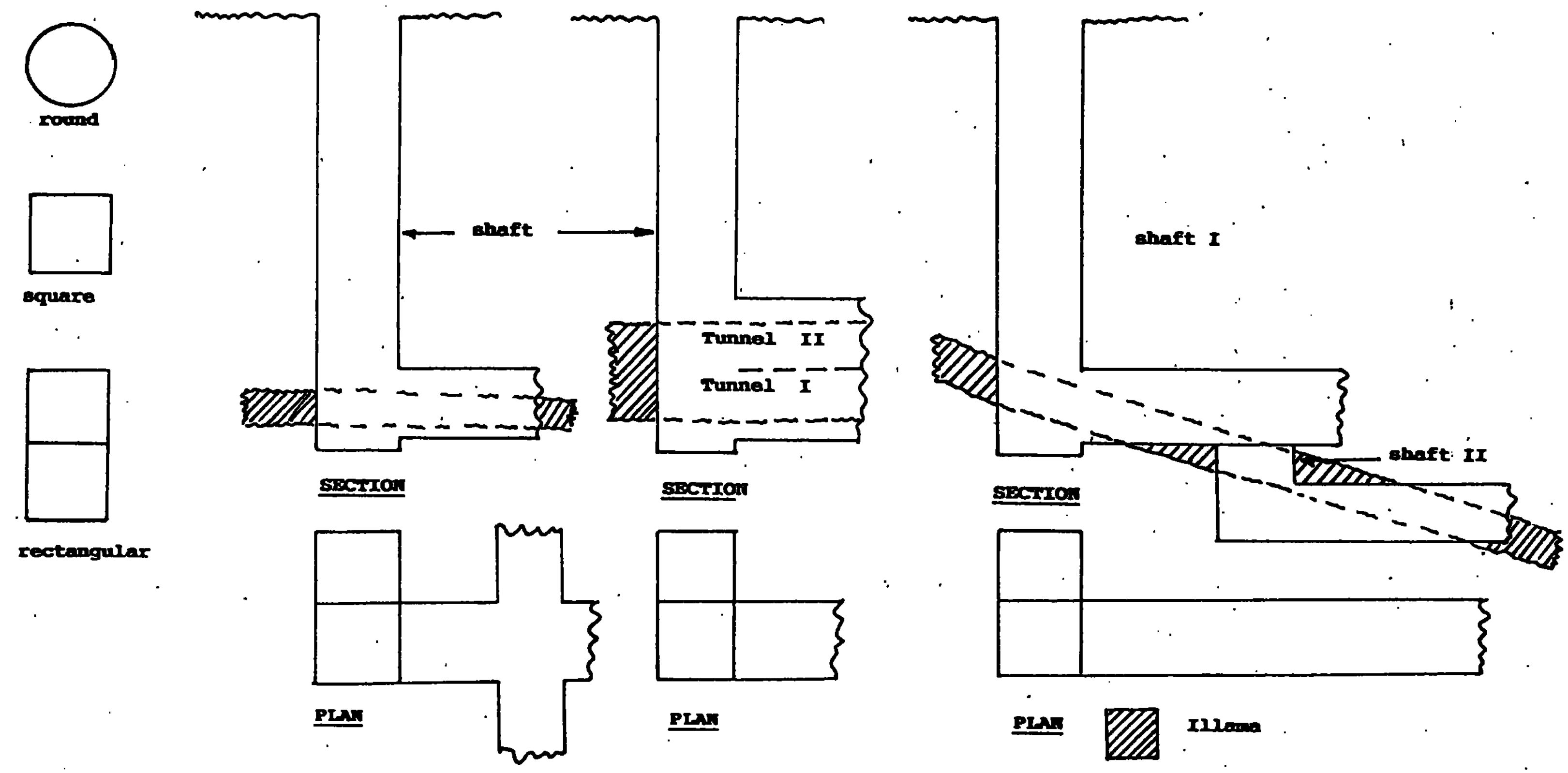

Fig. 4 (a)
Typical sections of shafts

Fig. 4 (b)
Shaft with tunnel in thin illama

Fig. 4 (c)
Shaft and tunnels in thick illama

Fig. 4 (d)
Shaft and tunnels in inclined illama

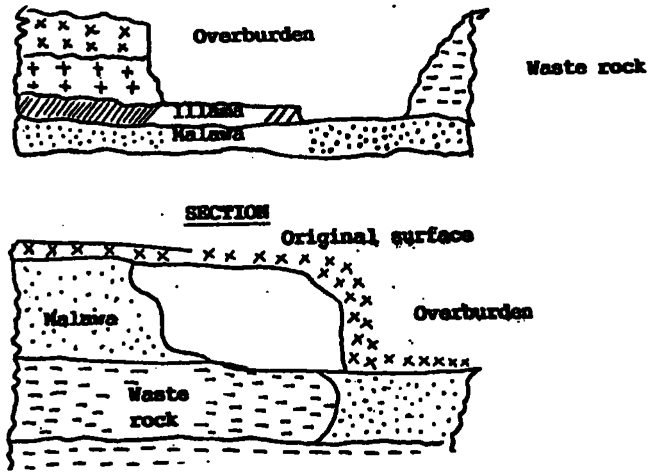

Fig: 5 - Strip mine of placer deposit

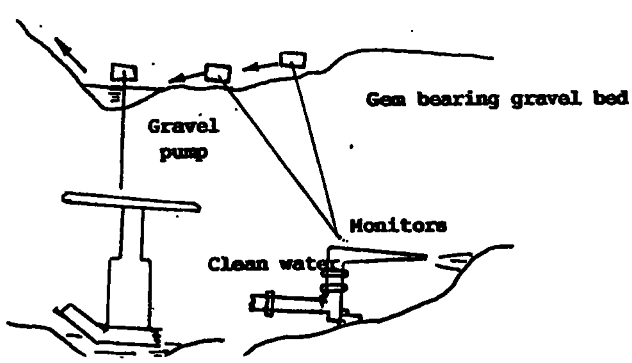

Fig. 6 - Gravel pump and monitors

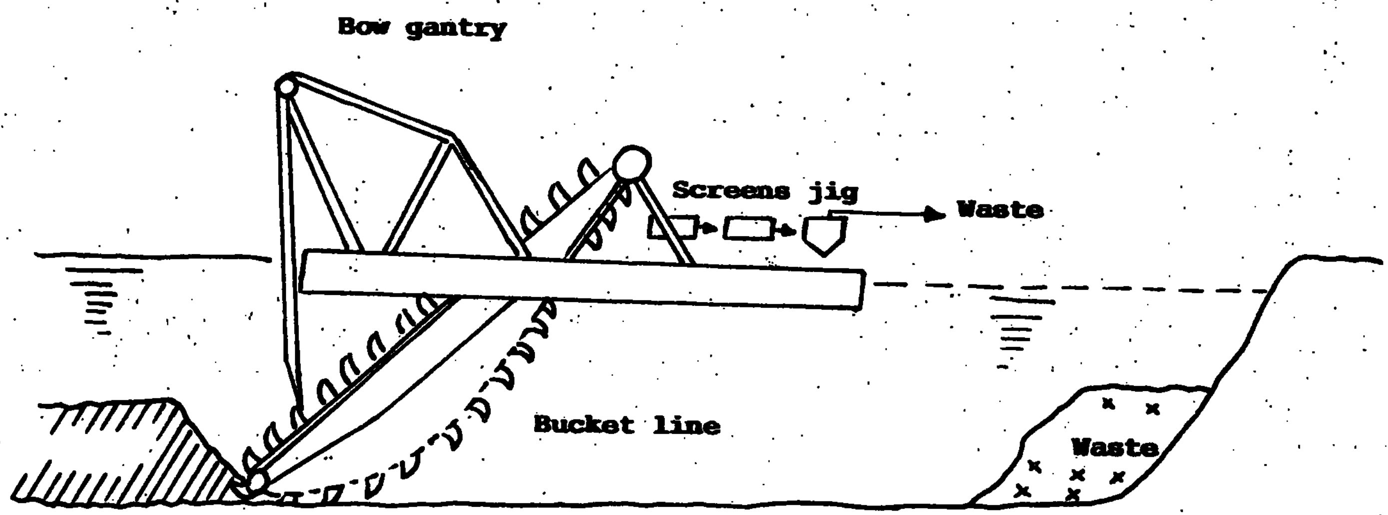

Fig: 7 - Bucket line dredger