torch to generate heat. After this temperature is maintained for some time the material in the crucible will melt and can then be poured out of the crucible to cool and harden into gold dore.

If concentrate is of poor quality (low gold percentage and high amounts of other minerals) the melt may need to be poured into another structure, such as a cupple, to separate the impurities from the gold. When melt is poured into the cupple, gold and other metals will sink as silicates and other minerals rise to the top, forming slag. When these materials harden the gold can be easily separated from the slag. The slag frequently contains addition gold that can be recovered through reprocessing.

Chemical Leaching
Gold extraction with borax

The use of chemical borax, also known as sodium borate, appears to be one of the more viable ways that have been proposed to reduce or stop the use of mercury by small-scale miners (Spiegel & Veiga 2010). Borax is used for cleaning purposes and is therefore commonly available. The reason for using borax in the smelting process of ore material is that borax reduces the melting point of metals and minerals. Under normal field circumstances small-scale miners cannot smelt gold, as they cannot create the high temperature required to smelt the ore. By adding borax to their concentrate, however, they can extract and smelt their gold. Gold purchasers already use borax to purify gold with a high content of mercury. This method is highly recommended for small-scale miners. However, it should be strictly followed in all its procedures to avoid harm to human health and environment. Many countries such as Phillipnes and Tanzania have used the method with significant and impressive recovery rate of gold.

Its Procedure: gold miners currently mix their gold concentrate with borax, followed by heating and smelting. The process works as follows: the gold ore is crushed, ground and concentrated as in the case of mercury-based extraction. However, the final product needs to have a very high gold concentration, above 90%, for the borax method to work. This requires skill, practice, and not least time. During testing of the borax method in Tanzania, two ways of smelting gold were applied. The first one involved using charcoal and a blower, the second one the use of acetylene gas.

Conclusion

Mercury continues to be used across many gold mines in Uganda. Its use is not properly regulated, managed and controlled. There are already complaints from different artisanal gold miners about the dangers of mercury. Mercury effects do not discriminate young, old, men and women at any slightest exposure and contamination. Its effects are lethal to many lives both miners and non miners. Mercury is a metal that has been associated with damage to the body including affecting the brain, lungs and kidneys, causing seizures impotence and infertility, miscarriages, children born with disorders. Mercury also leads to psychiatric illnesses, cancers and poor school performances in children whose mothers were exposed to mercury during pregnancy and finally it contributes to death. Adopting the alternatives technologies to mercury use is not only compelling but equally urgent.

Recommendations

- ACCC recommends that the government expedites the process of implementing the Minamata Convention on Mercury which it ratified. Its implementation would minimize the importation, sale and use of mercury that is destined for use among ASGM.
- ACCC recommends that the parliament and local governments should pass relevant laws that outlaw the use of mercury among ASGM.
- ACCC further recommends that the government tightens border controls so that mercury that is imported, disguised in other merchandise or and passes through porous borders is restricted and finally eliminated.
- ACCC further recommends that the government picks interests in promoting targeted awareness on the dangers of mercury and the available alternatives to its use.
- ACCC implores the need by the Ministry of trade and Mineral Development and related Agencies to promote and subsidize the alternative technologies to mercury use.
- ACCC recommends that the government through the parliament, Ministry of Finance and Trade should remove any tax on the alternative technologies to mercury use destined to gold mining and related processes.
- ACCC equally recommends that the gold mining license owners of all categories should be compelled to install alternative technologies in their areas of operations/mining sites.
- ACCC recommends the government should to provide alternative technologies demonstration sites for all other miners to benchmark from.
- ACCC recommends that NEMA should regularly inspect and supervise different mining sites to ensure effective usage, disposal of mercury, that is in instances where mercury is still used.
- ACCC recommends inter-Agency coordination to ensure that mercury alternatives are promoted at all levels of licensing.

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A WELL - MANAGED ENVIRONMENT FOR SUSTAINABLE LIVELIHOODS

A SNAPSHOT OF THE ALTERNATIVE TECHNOLOGIES TO MERCURY USE AMONG ARTISINAL SMALL SCALE GOLD MINERS (ASGM)

Vision: A Well - Managed Environment For Sustainable Livelihoods.

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ALTERNATIVE TECHNOLOGIES TO MERCURY USE IN GOLD EXTRACTION PROCESS FOR SMALL, MEDIUM & LARGE SCALE MINERS.

Dangers of Mercury use in Gold Extraction

AWARE that during gold amalgamation the metallic mercury evaporates. Some of the vapour is inhaled by people working in the vicinity and may over time cause irreparable damage to their health. **MINDFUL** that Mercury amalgamation in gold extraction process is dangerous to both human health and the environment. Methylated mercury is extremely harmful to the central nervous system, where it causes tremors, difficulty in walking, tunnel vision, psychological problems and eventually death. There is no cure for permanent mercury poisoning (Clarkson et al. 2003).**CONSIDERING** that mercury is a highly toxic substance that can last for a minimum of 100 years once released into the environment, **COGNISANT** that it needs to be handled carefully during storage, use, and the sewage it produces must be strictly controlled. **BEARING** in mind that mercury pollution will spread over large areas with mediums such as atmosphere, water, food chains, making it more difficult to control; it is thus **COMPELLING** that the alternatives to mercury use are prioritized and adopted by ASGM and line Ministries and departments in Uganda.

Alternative technologies to mercury use in Gold Extraction Process Commonly Used in Actual Production. The Gold extraction process free from mercury use is a combined process of various gold extraction methods that involve (A)amalgamation, (B) gravity separation, (C) flotation, (D) cyanidation) to extract gold from gold-bearing rocks highlited as follows;

Gravity Concentration Methods

Panning

Panning uses water to separate heavy gold particles from other lighter particles within a medium sized pan. In this process sediment or ore thought to contain gold is placed in a wide, curved pan along with water. The miner moves the pan in a series of motions designed to eject lighter sediments. The density of gold keeps it on the bottom of the pan as lighter material is ejected along with water. After a series of successful iterations have been completed, gold will be exposed on the bottom of the pan for the miner to recover. Panning works best when gold is coarse and well liberated. Under right conditions, panning can produce high grade concentrates or even liberated gold. Then miners can employ gold recover methods such as direct smelting, although many panning operations lead to directly recoverable gold. Panning offers miners a low cost method of gravity concentration but it requires time and skill to be effective. One of the major drawbacks to panning is that miners must pan small amounts of concentrate. Therefore, panning is often done after other methods of gravity concentration such as sluicing have completed.

Shaking Tables

Shaking tables are elevated tables tilted to one side with raised ridges running horizontally down their length. Mineral feed (crushed ore or sediment) and water are released at one end of the table. The water washes the feed down the table. As the material is washed down the table, specialized grooves trap gold and direct it to collection points on the side of the table as lighter minerals are washed away. During this process, the table is continually shaken by a motor to agitate the material and aid in the separation of gold particles. Shaking tables are very effective and can concentrate sizeable amounts of ore at a time, providing high grade concentrates and liberated gold, but they are also relatively expensive and require some experience to operate.

Spiral Concentrators

Spiral concentrators are specialized pans tilted on an angle with spiraled grooves. The spiral grooves in the pan lead toward the center where a hole is connected to a container to catch material. A motor is used to rotate the pan continually asconcentrate is fed onto the pan by an operator. A pipe extending horizontally across the pan sprays water along the surface of the pan as the concentrator spins. The water washes lighter particles down the spiral concentrator into a bucket while denser particles, including gold, are carried by the spiral grooves toward the hole in the center of the concentrator. After this process is repeated multiple times, the operator is left with a high grade concentrate, and often liberated gold. Spiral concentrators are relatively easy to operate but do represent a larger capital investment than panning or sluices.

Vortex Concentrators

Vortex concentrators use a rotating flow of water to separate lighter materials from a concentrate and remove them via a raised drain hole. A vortex concentrator is a circular tub with water input on the side of the tub and a raised drain in the center. The tub is filled with water until it reaches the level of the drain hole. Then concentrate is added in a thin layer around the bottom of the bowl. Water is then pumped into the side input, creating a rotating vortex of water that drains in the center. The vortex pulls lighter material up from the bottom of the bowl and out the drain hole. Dense materials such as gold remain in the bottom of the tub. After the miner sees only gold left on the bottom of the bowl the water source is turned off and the gold is ready to be removed. Miners must pay attention to the amount of water flow going into the tub. If it is too great the velocity of the water will carry gold particles out of bowl and this will lead to losses of gold. When vortexes are operated correctly, the result is a fine gold concentrate that is usually very high grade. Vortexes are easy to operate and are good at capturing fine gold that is hard to extract through other methods.

Centrifuges

A centrifuge is a vessel that rotates about a central point. It is used to separate materials in a mixture by density. To separate gold particles from a concentrate, concentrate is fed into the centrifuge through a pipe at the top of the machine in slurry of around 60-75% water and 40-35% solids. The material collects in a vessel in the center of the machine where high speed rotation creates force that moves the material up the sides of the vessel's walls. As the material is pushed up the sides of the bowl's wall, denser material like gold is caught in ridges while lighter material is ejected from the vessel. Centrifuges operate in cycles that can be preprogrammed or determined manually depending on the equipment and the material processed. After a cycle is completed, the miner can then extract gold from the ridges of the centrifuge vessel. For small scale centrifuges, cycles usually last around 0.5-2 hours. Operating a centrifuge takes skill as it must be tuned to the material it is processing. This is accomplished by adjusting feed grain size, rate of feed, rotation velocity, and cycle duration. Centrifuges can be more effective at concentrating gold than other methods of gravity concentration but are generally more expensive.

Magnets

Magnets can be used to remove magnetic minerals such as magnetite from concentrate. They can be used after or in conjunction with other method of concentration. One technique for extracting magnetic minerals is to place hand held magnets on the bottom of a pan containing dried concentrate to separate metallic from non metallic material. Care must be taken to avoid losing gold particles during the separation. It can be helpful to cover the magnet with a piece of paper. After magnetic minerals are attracted to the surface of the paper, it is removed to easily discard the metallic material.

Flotation

Flotation is usually used by large scale miners but can also be applied in small scale operations. It is a process that works best for processing complex ore types, especially ores that are difficult to process using gravity methods. In flotation, a mixture of slurry (crushed ore and water) and frothing agents are added into a flotation machine. A tube releases air into the tank of the machine and an agitator creates air bubbles at the bottom of the tank. Minerals that are hydrophilic, such as gold, attach to the bubbles' surface and are brought up to the top of the tank. Other minerals fall to the bottom of the tank and are discarded as tailings. Bubbles containing gold and other hydrophilic minerals accumulate at the top of the water level as froth. This froth is then scraped off to create a concentrate of gold and other hydrophilic minerals. Flotation creates high quality concentrates and is good at capturing fine gold. Flotation usually requires a substantial amount of capital investment. There are a variety of possible frothing agents. Depending on the chemical, specific precautions must be taken when employing the method to protect human health, and waste materials must be disposed of appropriately.

Gold Recovery

Direct Smelting

Separation methods, like the ones described above, if employed properly, should yield a high-grade concentrate with a large proportion of gold relative to other materials. However, this gold still needs to be separated from the other remaining minerals before it can be sold. At this point in the process, direct smelting can often be employed as the final stage of gold recovery. In direct smelting high-grade concentrate is heated until the gold melts. The liquid is then cooled to form a solid mass of gold dore, a semi pure gold alloy, that can reach upwards of 95% purity.

To perform direct smelting, a miner, community mining consortium, or processing shop employs a crucible, a high temperature bowl designed for smelting. Gold concentrate is combined with a flux, such as borax or other materials of mixtures, in the crucible. The flux acts to decrease the melting temperature and viscosity of non-gold minerals in the concentrate so they are more easily separated from the gold during the cooling process. Small amounts of concentrates, usually around 50 to 100 grams, are used in direct smelting. Concentrate and flux are heated in the crucible to the temperature at which gold melts, 1065 degrees Celsius. Miners usually use a blow

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