Chapter 7
Environmental Effects of Mercury

How mercury contaminates the environment

When gold miners use mercury to amalgamate gold they should be aware that they can easily contaminate themselves, their families, and their neighbors, as well as people living far way from their worksites. The way the contamination takes place depends on how the miners do their work. For example, if the whole ore is amalgamated and discharged without adequate settling ponds, or if mercury contaminated materials are dumped directly from a raft into the river, mercury will be carried downstream and dispersed over a very wide area where it can transform into methylmercury in the sediments at the bottom of the rivers, lakes or streams. Methylmercury is easily absorbed by worms, snails and insects and becomes highly concentrated in fish, especially the piscivorous species (fish that eat other fish). Eating fish contaminated by mercury from ASM activities can pose a great health risk to people living downstream of mining areas. Likewise, mercury vapor emitted from open pan amalgam burning is dispersed in the air. Most of the vapor settles onto the ground and can contaminate soils up to two kilometers downwind from burning. Some vapor however travels long distances and comes down with rain. If the miners amalgamate concentrates in pools, mercury tends to be concentrated within a relatively small area, forming a local "hotspot", i.e. a site with high concentration of mercury-contaminated material.

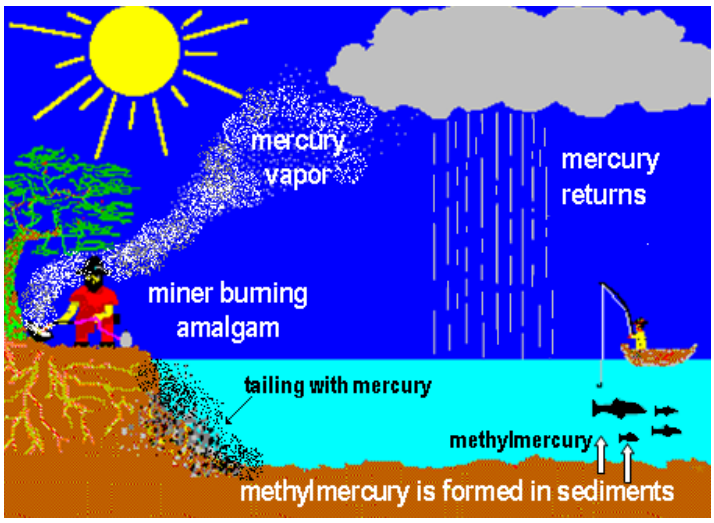

Fig.7.1 – Mercury emitted by miners can be transformed into methylmercury to be accumulated in fish

Environmental mercury contamination can be caused by present-day mining, or by historic and abandoned mining sites that continue to emit mercury to the air or water for many years after mining has ceased. It is difficult to obtain reliable, quantitative data about how much mercury is released from active artisanal gold mining sites because miners do not freely provide information about the amount of mercury they use. At abandoned sites, determining the extent and magnitude of mercury contamination is even more difficult.

Analyses of water, sediments and soils surrounding mining sites can provide only estimates of the amount of mercury released. In order to obtain reliable figures about the amount gold produced or the amount of mercury lost, it is necessary to build a trust relationship with miners to guarantee access to their mining and processing sites. Gaining trust takes time, but without it, it is very difficult to understand how much mercury is used and lost at each unit of operation. Ultimately, remediation of mercury contaminated sites may be necessary to prevent further exposure of human populations, and to ensure that mercury does not continue to be released into the environment and eventually become methylated.

Protect your environment

Mercury released during amalgamation in ponds or next to rivers, and especially during burning of amalgam, contaminates the soil and water of the local environment. This mercury continues to evaporate from soils around amalgamation areas and will continue to contaminate the air that is breathed by miners and their families. Mercury lost during amalgamation and during burning can be washed into ponds and streams. Mercury deposited in water can be transformed into methylmercury which builds up in fish. While the fish themselves are not affected, frequent consumers of fish downstream from artisanal gold mining areas can become mercury intoxicated--it is irresponsible to contaminate an environment and subject non-miners and innocent people to mercury contamination.

When amalgam is burned, mercury vapor is carried by the air to very distant places. Likewise, when mercury is used with copper plates (and other forms of whole ore amalgamation) the sand and silt flowing over the plates scours mercury from the plate and carries it in the river to regions far from the mines. **Microscopic droplets of mercury become attached to fine, muddy sediment particles which travel easily downstream, far away from mining areas**. Even if amalgamation is conducted in enclosed ponds, elemental mercury adhered to small sediment particles can be washed into regional stream systems during rainy periods. Mercury attached to the fine particles of sediment can

travel kilometers and part of it is oxidized. In a slow-moving area of the stream, the particles sink and find reducing conditions (rich in organic matter) at the bottom of the river. Then, through a biological process, bacteria can produce methylmercury. The methylmercury formed does not stay in the water and it is quickly taken by organisms and it goes up into the food chain to become concentrated in fish, especially the carnivorous species. The more sediment particles introduced to the water, the more that mercury is transported to other places downstream. (Note that metallic mercury is not soluble and does not stay in the water. There is no health risk from drinking clear or filtered water from streams. However, because mercury can be attached to the fine sediment particles, it is not advisable to drink dirty water.)

People must not eat fish that have been grown in amalgamation ponds or near streams that might receive mercury contaminated water. Amalgamation should only occur in ponds that are dedicated for this purpose; similarly, fish should only be grown in special dedicated ponds. Water that has been contaminated with mercury or that has been used for amalgamation must NEVER be used for cooking, bathing or drinking.

It is important that forests around mining areas are protected and are not cut down. These “buffer zones” allow the sediments to settle locally, preventing the transport of mercury attached to fine muddy particles from reaching streams or lakes where it can be transformed into harmful methylmercury. Similarly, it is also critical that residual mercury contained in amalgamation ponds does not reach open aquatic systems; efforts should be made to site amalgamation ponds in safe places, protected from flooding during rainy seasons. Hg-contaminated tailings should be disposed in cement-lined ponds. Where cement-lined ponds are not available, a “harm reduction approach” may be necessary--in some situations it may be sufficient to contain amalgamation tailings in covered 1m-deep holes lined with plastic and compacted red earth (the iron oxide in red earth easily attaches to elemental mercury, holding it in place).

Basic knowledge for miners

- Miners should be aware that mercury amalgamation can contaminate
    - miners themselves
    - their families
    - their communities
    - people living a long distance away
    - the environment
- Burning amalgams in open pans can cause significant mercury soil contamination up to 2 km away

  - Mercury vapor can travel even greater distance and fall down with the rain
- Amalgamation in pools or ponds tends to keep mercury contamination in a relatively small places or "hotspots"
- Dumping amalgamation tailings into rivers carries the mercury far away
  - Mercury in these streams transforms into methylmercury through chemical and biological reactions in the river sediments
  - Methylmercury builds up worms and bugs that in turn are eaten by fish - in general, this mercury doesn't make the fish look sick
  - People downstream from ASM areas who eat these apparently healthy (but poisonous) fish can become very poisoned by methylmercury
- Contaminated soils and tailings release Hg long after mining has ceased
  - This poses a long-term hazard to miners and local communities
- Metallic mercury is not soluble in water and quickly settles to the bottom.
- Mercury does not stay in solution in water
- Mercury stays attached to small suspended particles
  - Water that is filtered, or is clear generally contains only very low amounts of mercury
  - Dirty water has silt particles that can hold tiny mercury particles in suspension
  - Do not drink unfiltered/unclear water in ASM areas
- Never use copper amalgamation plates
  - Sand in slurry scours the mercury from the plate and carries it with the tailings
  - Mercury lost from copper plate amalgamation attaches to tiny pieces of sediment/silt and can be carried far away.
  - Cyanidation circuits make the mercury more easily methylated
- Never put mercury in centrifuges or ball mills
  - This pulverizes mercury which is lost with tailings
  - Pulverized mercury does not amalgamate gold
- Never discharge amalgamation tailings into water courses
  - Mercury-contaminated tailings can be carried to long distances
  - Residual mercury in amalgamation tailings can be transformed into methylmercury
- Always make amalgamation distant from streams, rivers or lake
- Do not dump amalgamation tailings (contaminated with Hg) into water streams.
- Methylmercury can build up in fish

  - Do not eat fish that have been farmed in active or abandoned amalgamation ponds
- Don’t cut forests around mining areas because the soil in these forests can help keep the mercury from entering the streams
- Dispose amalgamation tailings in cement lined ponds
  - If necessary dispose amalgamation tailings in pits dug in red clay soils (iron rich laterites)—these soils contain iron oxides and clays that hold mercury in place
    - Dig pits at least 1 meter deep; line pit with red clay soil and plastic sheeting; cover it with red clay soil

Chapter 8
Health Consequences of Mercury Exposure

Mercury in the environment

Mercury is a naturally occurring element that is present in low concentrations in all living things. Elemental mercury is a heavy, silvery liquid that has had many industrial purposes, and is used in thermometers, switches, fluorescent lights, and to manufacture caustic soda. Humans have also known how to use mercury to amalgamate gold for at least 2,000 years.

Mercury is the only metal that is present as a liquid at room temperature. It also has the lowest boiling point of all metals, which is why it evaporates or "burns" easily. Mercury vapor is colorless and has no odor and is extremely toxic. Mercury is also very "sticky". When evaporated, particles of mercury easily stick to surrounding furniture, walls, skin and clothing. Clothing worn during burning can continue to emit high concentrations of mercury for many hours and can contaminate other areas, including the air your family may breathe.

Natural processes, especially volcanic activity and natural forest fires, release about 1/3 of the global annual contribution of mercury to the atmosphere. Human activities, especially burning of coal and using gas in vehicles and in generating stations, contribute more mercury to the atmosphere than the mercury that comes from nature. Mercury released by small-scale mining activities around the world is a very significant source of atmospheric mercury and must be reduced. Mercury used in gold extraction is often discharged along with mine tailings and during burning of amalgams. Mercury released during burning of amalgams can seriously contaminate local environments including homes, neighborhoods, clothing, and food. Mercury is poisonous and can be easily absorbed by humans and animals. Mercury released to the environment, whether naturally or by human activities, is transported around the world and is eventually deposited in rivers and lakes--ultimately some of this ends up in fish and other animals consumed by people.

In some places, the major route of exposure to mercury is through fish consumption. The chemical form of mercury in fish is different than the *elemental mercury* found in thermometers or used in mining. This form of mercury is called *methylmercury* and it is considerably **more** toxic than elemental mercury. Fortunately, only a small portion of elemental mercury released or lost into ponds and rivers becomes transformed into methylmercury. However, because of the extreme toxicity of this compound, it is very important that losses of mercury to the environment are controlled or

eliminated, to avoid contaminating the environment and poisoning animals and people who consume contaminated fish. It is especially important that miners are aware that mercury released from mining can poison people not involved in mining.

Human exposure to mercury

For miners, mercury can be absorbed directly through the skin during the amalgamation process. However, the main route of exposure in small scale and artisanal miners is through inhalation of mercury vapors during burning of mercury – gold amalgams. The absorption of mercury vapor is very dangerous and can lead to serious health problems. Most people in the world however aren't directly affected by mining, so fish consumption is the major route of exposure for them to mercury (as methylmercury). Both mercury vapor and methylmercury affect the brain, nerves, senses (e.g., vision, hearing) and organs (liver, kidney, glands).

Elemental mercury vapor has no color and no odor. Mercury sticks to clothing worn during burning and will continue to be a source of mercury vapor long after burning has ceased. When breathed, mercury is absorbed by the lungs and is passed directly into the bloodstream where it is carried to all organs of the body. The body retains 80% of all inhaled mercury vapor. Wearing a dust mask does not afford any protection from mercury vapor. Mercury has no biological purpose and the human body recognizes mercury as harmful. The liver and kidney attempt to rid the body of mercury that is either inhaled or absorbed through the skin. The liver attempts to detoxify and get rid of the mercury via the digestive system. The kidneys attempt to get rid of mercury in the urine. However, mercury can build up in the body, especially the kidneys, and can cause serious damage.

Mercury levels in urine are the best indicators of recent inorganic (metallic) mercury exposure, especially from burning of mercury. Measuring mercury concentration in the breath is another useful means of determining recent exposure. A person who has recently burned mercury or has been burning for some time will have strongly elevated mercury concentration in their exhaled breath, as the body tries to rid itself of the mercury in the bloodstream. Elevated mercury in blood or hair is regarded as a good indicator the mercury exposure has been from eating fish containing methylmercury.

Analysis of urine, blood and hair is a common means of determining the amount of mercury in an individual and assessing potential risk. Trainers of

miners should understand the meaning and usefulness of these kinds of analyses.

Urine –The normal units of reporting mercury concentration in urine are as µg Hg/g creatinine. That is, mercury is adjusted or standardized according to the amount of creatinine (an amino acid) in the urine so that results are not affected by dilution (e.g., if someone drank a lot of water they would dilute the urine and therefore the Hg concentration). The World Health Organization (a United Nations organization), considers 4 µg/L of total mercury (not adjusted for creatinine levels) in urine to be normal. A concentration higher than 5µg Hg/g creatinine is risking health effects; at concentrations above 20µg Hg/g creatinine, there is definite cause for concern and probable risk of mercury intoxication.

Blood – Mercury levels in blood are the best indicator of total (inorganic and organic) mercury exposure over time. Blood is more difficult to measure in people because specialized equipment is necessary (e.g., sterilized needles, special vials containing chemicals to prevent coagulation, etc.,) and someone trained to collect blood is required. For these reasons, measuring mercury in blood is less common than measuring in urine or hair.

In blood, a concentration of 5 – 10 µg/L mercury is considered normal. At concentrations exceeding about 200 µg/L of mercury there is a 5% risk that some neurological damage has been suffered. This means that one person in 20 with a mercury concentration in blood exceeding 200 µg/L is likely to demonstrate some impairment of brain function, such as memory loss or lack of coordination of the hands.

Hair – Measuring mercury in hair provides an excellent record of exposure to mercury, especially from eating fish. Mercury becomes very concentrated in hair which is one of the routes that the body uses to rid itself of mercury. Most of the mercury in hair is methylmercury, which is the same chemical form as is found in fish. Mercury is much more concentrated in hair (about 200 to 300 times) than in blood. It is also much easier to measure mercury in hair than in blood, because no special equipment, expertise or preservation is required to collect the samples. Because hair grows at an average rate of 1.3 cm per month, a record of exposure to mercury can be gathered by analyzing the hair in different segments, to acquire a history of exposure.

In ASM communities, especially among burners of amalgam, mercury in hair comes partially from vapor sticking to the hair, and partially from fish

consumption. To eliminate this external contamination by mercury vapor, hair samples should be washed with neutral detergent, acetone and water to eliminate mercury stuck to the surface of the hair.

The concentration of Hg in hair among unexposed people is 1–2 μg of mercury per gram of hair. If a pregnant woman's hair contains 20 μg/g or more there is a strong possibility that the developing fetus will be affected. Recent research considers 5 μg/g Hg in hair as the upper limit guideline for pregnant women, to prevent damage to the fetus.

Uptake and elimination of mercury

Mercury is a potent neurotoxin; it impairs and destroys the brain and nervous system and other organs. The nervous system is made up of many different parts, so symptoms vary depending on the individual and on the amount of mercury and amount of time a person has been exposed. Mercury is very dangerous, especially to pregnant women and children. Mercury is absorbed into the lungs during inhalation where it passes directly into the bloodstream; it can also be absorbed though the skin during the amalgamation process. The bloodstream carries mercury throughout the body, including the brain and nervous system. Mercury also passes through the placenta in pregnant women, affecting the developing fetus. Fetuses and children are at greatest risk because mercury impairs proper development of nervous tissue and can cause many symptoms ranging from mild reduction in intelligence and coordination, to distortion of limbs, severe retardation and in severe cases, death. The effects of fetus exposure to mercury may take months or even years to appear. In the later years the child may develop learning disabilities.

Inhaled mercury is also deposited in the kidneys. Elimination of mercury from the body is mostly via urine and feces, but some is exhaled from the lungs as mercury can also leave the bloodstream the same way it was absorbed. Elimination of most inhaled mercury takes several weeks to a number of years. If a burner has been using or burning mercury amalgam for a long time, mercury will build up in the body. The longer a person has been exposed, especially burners, the longer it will take for the body to rid itself of mercury. This may take many years and some of the effects of exposure to mercury may be irreversible. The longer that a person has been exposed, the greater the likelihood that the person will be affected.

Medical indicators of mercury exposure

The most toxic form of mercury is methylmercury which is a product of transformation of metallic mercury discarded by miners (and other industrial and natural sources) into the environment. Methylmercury does not stay in water as it is accumulated by the aquatic bugs and animals very fast. There have been no cases of human mercury poisoning through drinking water.

The health effects (and symptoms) of mercury vapor and methylmercury intoxication are somewhat different. As seen above, the main way in which a person is contaminated with metallic mercury is through the vapor emitted by gold miners and gold shops. As methylmercury is absorbed by fish, a person can be contaminated when eating fish containing even moderate levels of methylmercury. The world's worst accident with methylmercury occurred in the 1950s and 1960s in Minamata, Japan, when a plastic factory discharged waste water containing methylmercury into an ocean bay, contaminating the fish. Eating these fish killed thousands of people and made many children retarded.

It is often difficult to diagnose if a person is intoxicated with mercury vapor. There are many things that can confuse a diagnosis, including malaria, alcoholism, and malnutrition. The likelihood that a person is affected is highest among the following people:

- amalgam burners
- people who have used or burned mercury for a long time
- children of mothers who were exposed to high concentrations of mercury during pregnancy
- children routinely present during burning of amalgam, and
- people who consume large amounts of fish from mercury contaminated ponds or rivers.

Analysis of mercury in urine, blood or hair does not necessarily indicate or diagnose if a person is intoxicated. A person who has ceased burning for more than a year, but who has been exposed to mercury for a long time, can measure low levels of mercury in blood or urine, but may still be suffering the effects of metallic mercury poisoning. The brain or other organs may have suffered irreversible damage and this cannot be detected by measuring blood or hair. Similarly, urine, blood and hair analyses cannot be relied on to diagnose people poisoned with methylmercury.

Medical exams can diagnose whether or not a person has suffered effects of exposure to mercury. A medical exam consists of an initial questionnaire about

the health history of the individual followed by physical and neurological examination. Questions related to health history are needed to exclude participants with diseases that might confuse a diagnosis. Individuals are administered a series of tests that are designed to detect effects of mercury poisoning. These are simple tests and local health care professionals should be trained to perform such a series of tests in local health offices. Examples of clinical tests consider the following:

- Trouble with coordinated walking (ataxia)
- Tremors
- Test of alternating wrist movements
- Test of the field of vision.
- Reflexes: knee jerk reflex and biceps reflex.
- Finger-to-nose test
- Eyelid tremor
- Tongues tremor
- Excessive salivation
- Numbness of fingers and toes

Examples of neurological tests include

- Short-term memory and concentration tests
- Co-ordination tests
- Tests of the intensity of tremors
- Ability to draw shapes and draw between lines on a page

Properly trained individuals can detect mercury intoxication and these tests do not demand special equipment. However, these tests should only be administered by an experienced health professional because proper analysis and interpretation of data is essential. Even then, sometimes a definitive diagnosis is sometimes not possible. However, if a person has burned mercury for some time and displays many of these physical or neurological symptoms, mercury intoxication is the likely cause.

Symptoms of mercury vapor exposure

The major health concern of elemental mercury vapor poisoning is the brain, central nervous system and kidneys. Damage is often permanent and irreversible. Inhaling large amounts of metallic mercury vapor, such as when miners are burning amalgams in open pans, causes acute exposure. This can cause many symptoms including difficulty and pain when breathing, chest pains, coughing, pneumonia, and kidney failure. Chronic exposure to smaller

amounts of mercury over a long period of time includes many symptoms including:

- headache
- metallic taste in mouth and bleeding gums
- tremor of fingers and toes
- poor coordination of movement of arms and legs
- difficulty writing
- unsteady walking
- slurred speech
- blurred vision and long-sightedness
- dizziness
- hearing loss
- impotence in men
- loss of coordination of hands and fingers
- inability to perform rapid alternating movements

Psychological symptoms include insomnia, irritability, fatigue, forgetfulness, difficulty concentrating, lack of energy, exaggerated emotional response, loss of interest in sexual relations, melancholy, and depression. These symptoms may not always be consistent and differ from person to person.

Unborn and young children are at the greatest risk when exposed to mercury because their organs, nervous tissue and brains are still developing. Mercury inhaled or absorbed though the skin becomes accumulated in the growing brain and can result in permanent damage to the brain, causing a reduction in intelligence, coordination, and impaired development. In severe cases of exposure, this can result in severe retardation or death of the child.

Consequences of mercury exposure

There are both immediate and long-term effects of using mercury in the gold mining process for miners, mining families and the whole community. Typically there is a low level of contamination that affects all of the community members, especially near burning areas. If mercury is used or amalgam is burned inside a house, this results in contamination of the house, the miner and his/her family. **Burning amalgam in the home or enclosed areas must be avoided**. When any burning of amalgam is conducted, a retort must be used to contain and recycle mercury in order to reduce exposure of the workers and neighbors to mercury vapor. The risk to women, unborn children and young children is particularly high, especially when burning is performed by women or children in the home. Even small exposure to mercury is dangerous. If

pregnant women are exposed the child may suffer minor deficiencies in metal function even though the mother may have very mild or no symptoms at all. In addition, if the new mother continues to be exposed to mercury, this mercury will be passed from mother to baby via breast milk, causing ongoing further poisoning of the baby.

Children should not be exposed to mercury and should not be directly involved in mining activities. Exposure to mercury, hard physical labor, unsafe mines, and lack of safety equipment puts children at risk and exposes them to conditions they cannot control. This is unfair to an innocent child. There are great long-term benefits to children, families and communities when ways to prevent mercury exposure are adopted by miners.

ASM communities are also faced with a variety of other challenges, such as malnutrition, diarrhea, malaria, tuberculosis, parasites and other diseases and afflictions. The sometimes subtle symptoms of mercury poisoning may be overlooked because of the stress of facing acute illness, accidents and everyday poverty.

As already mentioned, an additional risk posed to ASM communities is sometimes exposure to mercury via fish. Fish are an excellent primary source of source of animal protein and in some places are consumed frequently. A portion of mercury lost during amalgamation can become transformed into toxic methylmercury which accumulates in fish. In general, carnivorous fish accumulate more methylmercury than plant eating fish; large carnivorous fish tend to contain the most methylmercury which they absorb from the many smaller fish they have eaten. Following is a list of fish species from Indonesia that can safely be consumed and those that should be avoided. (Miners can work with local health and environmental officers to identify the fish that are the safest to eat in their regions.) Under no circumstances should fish be consumed from the same ponds in which amalgamation is conducted.

Examples of fish safe to eat in Talawaan, Indonesia

Fish Safe to Eat	**Fish to Avoid Eating**
Nilem (detritivorous)	Tahuman (piscivorous)
Patin (detritivorous)	Tampalbor (omnivorous/piscivorous)
Saluong (herbivorous))	Buang putih (omnivorous/piscivorous)
Gete gete (omnivorous)	Cakalang (piscivorous)
Jelawat (omnivorous)	Telak or Gabus (piscivorous)

If any of the above, "safe to eat" fish are grown in amalgamation ponds, they should **NOT** be eaten.

Treatment of mercury poisoning

There is no cure for mercury poisoning. Western medical treatment for acute and chronic mercury poisoning is very expensive, and cannot reverse any damage done to the brain. The only steps that can be taken are to remove the person from any more exposure. Traditional herbal treatments are being researched, however, there is no proven solution available at this time. For now, the best treatment is education and prevention. Most importantly, this involves awareness of the hazards of exposure to mercury, especially to pregnant women and children.

Protect yourself and your family

The keys to protecting yourself and your family from mercury contamination involve simple behavioral changes or adoption of simple technologies that can not only reduce the risk of contamination, but improve gold recovery as well as recover mercury for re-use (see chapters 3, 4 and 5 above).

The following list provides a number of simple behavioral changes that if adopted can significantly reduce exposure to mercury. It is very important to prevent or minimize exposure to mercury, especially the mercury vapor produced during the burning of amalgam. It is particularly important to prevent exposure of women and children to Hg.

- Behavioral changes are essential to minimize exposure: While recognizing that behavioral change is difficult, miners should be encouraged to burn amalgam as far away as possible (perhaps 200-300 m) from other people, homes, schoolyards, churches, mosques or temples. Do not burn amalgam inside the home. Never burn amalgam in the kitchen.
- If you burn amalgam, **USE A RETORT: A simple and effective retort can be made from kitchen bowls.** If a retort is not available, burn away from people and change clothes after burning and store them in a bag away from the home; women and children must not burn and should be kept far away from burning areas.
- Do not amalgamate in a river or pond that is used for drinking, cooking, washing or growing fish. Small amounts of mercury are always lost during amalgamation and can be transformed to the much more toxic methylmercury form which accumulates in fish.

- Amalgamate in a pond dedicated for this purpose. Locate the pond well away from a river or lake to prevent small amounts of mercury from being washed into the river or lake during the rainy season.
- Burn amalgam in a well-ventilated area equipped with a fume hood and if available, equipped with a carbon filter.
- Avoid breathing mercury vapor! Using a mask does not prevent your lungs and body from absorbing mercury.
- Mercury vapor is present in high concentrations around the burning area for a very long time after burning has taken place. You and your family will be exposed to mercury long after burning has ceased.
- Adopting new technology can minimize or prevent exposure to mercury. This can include the use of an amalgamation barrel to amalgamate concentrate (or more simple solutions like the use of gloves or a stick to mix mercury with concentrate) and the burning of amalgam in a retort which will recover mercury for later use and save you money.
- Consider creating an amalgamation center for your community – a central place where burning with retorts can minimize exposure to people, and which will reduce the size of the area of contamination and reduce contamination of the environment.
- Certain fish species naturally have higher mercury than other fish species. Avoid consuming fish that eat other fish (i.e., carnivorous fish) and instead select fish that prey on insects or plants (e.g., carp, tilapia, minnows, some catfish).
- Spread the knowledge. Tell others what they should and should not do when using mercury

Basic knowledge for miners

- Mercury (Hg) is a neurotoxin and very dangerous to humans and their environment
- Gold miners are exposed to Hg mostly by breathing mercury vapor released when burning amalgam in open pans or handling copper-amalgamating plates.
- Mercury can also be absorbed by the skin by handling it without gloves.
- Mercury vapor is invisible and very easily absorbed by the lungs

- Levels of toxicity of undue mercury vapor exposure can be measured by testing urine of people
- A person who has ceased burning for more than a year, but who has been exposed to mercury for a long time, can measure low levels of mercury in blood or urine, but may still be suffering the effects of mercury poisoning.
- Having a history of exposure can cause long term damage to nervous system and kidneys, and even death
- Mercury is the most dangerous to unborn babies and young children. Therefore pregnant women must be also protected from mercury
- There is no cure for mercury poisoning
- The best treatment is prevention
- Do not burn mercury burning near homes, children or women
- Use retorts (outside) when burning mercury
- Create and share amalgamation and burning sites away from homes
- Do not amalgamate near water sources, or where water can carry sediments into rivers
- Use the most effective amalgamation methods available
- A biological (bacteria) reaction transforms at the bottom of the river and lake sediments many forms of mercury into methylmercury
- Methylmercury is one of the most toxic substances of the world
- Methylmercury does not stay in water as it is accumulated by the aquatic bugs and animals very fast. There have been no cases of human mercury poisoning through drinking water
- Methylmercury accumulates in small organism and it goes up on the food chain, i.e. it becomes more concentrated in carnivorous species
- Avoid eating carnivorous fish in contaminated areas

Chapter 9
General Health Concerns of Artisanal Mining Communities

The United Nations Millennium Goals reflect the poverty and resulting malnutrition and lack of health care of almost 4 billion people who are struggling to survive on less than US$ 2/day. Artisanal mining communities are typical of the rural communities that the Millennium Goals seek to benefit.

- 6 million children die from malnutrition before their 5th birthday every year
- 6,000 people die from HIV/AIDS everyday
- 8,200 people are infected by HIV everyday
- 300 – 500,000,000 people are infected with malaria each year
- 2,000,000 die from malaria each year
- 800,000,000 people are hungry everyday 300,000,000 are children
- 270,000,000 of these children suffer long-term malnourishment and micronutrient deficiency
- TB infects someone every second
- 5 – 10% of these people become sick or infectious at some point in their life
- If left untreated someone with active TB will infect 10 – 15 people each year
- 2,600,000,000 people (40% of the world's total population) do not have basic sanitation
- 1,100,000,000 people drink from unsafe water sources daily
- 5,000,000 people (mostly children) die of water-borne diseases every year

With this in mind we are reminded that for whatever reason we find ourselves working and training in artisanal mining communities, whether as miners or as mining engineers, technical experts, economists or teachers, we need to work with the social and health issues associated with poverty. The social issues include: frequent illegality of artisanal mining, frequent relocations of individuals, poor infrastructure, loss of adults due to disease and accidents, breakdown of family structure, gender inequity, child labor, abuse of alcohol and other drugs, gambling, prostitution and violence. The most significant illnesses that are responsible for much suffering and premature death are malaria, HIV/AIDS and TB. These are exacerbated by malnutrition, inadequate access to clean water and sanitation and by the social issues.

Malaria

Malaria is a serious, potentially fatal, contagious disease that is transmitted from one infected person to another through the bite of female Anopheles mosquito. It is caused by parasites, which are very small and can only be seen through a microscope. They feed on blood cells, invade them and ultimately destroy them. This causes anemia, loss of red blood cells, which are responsible for transporting oxygen around the body. The parasites can move to internal organs including the brain. More than 40% of the world's population is at risk for malaria.

Malaria, typically has three stages: 10 days to 4 weeks after being infected a person first experiences a headache with chills and shivering for about one hour. This is followed by a fever of 40°C or more. At this stage the person is weak, has warm, dry, reddened skin and may be delirious for three or more days. Finally the person begins to sweat, and the temperature goes down.

People suffering or recovering from malaria need plenty of liquids and food. This is especially true for children. Malaria is very dangerous for pregnant women, because it causes severe anemia, miscarriages, stillbirths, low birth weight and maternal death. If possible children and pregnant women with fever should receive immediate medical care and treatment. Children with fevers should be kept cool, by bathing them with cool (not cold) water frequently, which encourages body heat loss.

There is no vaccination for malaria yet, although preventative medication is available in some areas. When someone is ill with suspected malaria, treatment should start as early as possible, because delaying can make the disease more dangerous. Once medical treatment is started, it is essential that the full course of recommended medicine be taken. Medical treatment is not universally available in artisanal mining communities. So, taking action to stop mosquitoes from breeding near homes can help protect families and communities. These steps are much more successful when groups of people work together because mosquitoes fly all over the place. Mosquitoes breed within 2 km of where they bite people. Swamps, ponds, puddles, pits, drains, latrines, water pots, tanks, inside old car tires, animal water containers, in moisture on grass and bushes, and anywhere else where there is stagnant still water are potential breeding grounds. Covering openings in containers and tanks, filling in puddles, tipping out unwanted water, clearing bushes near houses and building houses more than 2km from stagnant water, all prevent malaria. The introduction of mosquito eating fish into ponds can be effective. Putting a little oil on the surface of pools or marshes stops the mosquitoes from breeding. In addition,

the use of window and door screens protects the whole house from mosquitoes. If this is not possible, mosquito nets over the beds of the most vulnerable are very effective. These screens and nets can be treated with biodegradable pyrethroid insecticide, which kills mosquitoes.

Tuberculosis ("TB," "consumption")

Tuberculosis is a serious, potentially fatal, contagious disease that spreads from one infected person to another through the air. One third of the world's population is infected with the TB bacilli, of which 5 – 10% will develop the disease and become ill.

TB spreads most rapidly in areas where large groups of people are living together and sharing air. The TB bacilli can travel through the body of an infected person causing disease in many organs including skin, backbone, lungs and abdomen and glands of the neck, causing growths. Frequent early signs of tuberculosis include: a cough lasting over three weeks, slight fever in the evening with sweating at night, pain in chest or back and increasing weight loss. In children there may be no early cough, but instead children experience weight loss, frequent fever, swellings in neck, energy loss, lighter skin color and seizures. People who have TB and HIV/AIDS are much more likely to get sick as each disease speeds up the other.

TB is diagnosed by skin and spit tests. When one person in a home is diagnosed it is a good idea to test everybody else if possible. Medical treatment for TB exists, but is not always available in artisanal mining communities. When treatment is started it is essential that the prescribed medicine be taken for at least 6 months as ordered. Sometimes people don't want to take medicine when they feel better, and unfortunately this results in TB bacilli that are resistant to the medication. Someone who has TB needs to rest, eat a diet with protein and vitamins.

Having the ill person always cover the mouth when coughing, and sleeping in a separate room can prevent other family members from contracting TB. In addition having children vaccinated with BCG (Bacille Calmette-Guérin) and giving them plenty of nutritious meals will help prevent infection.

HIV/AIDS

HIV is a serious, potentially fatal, communicable disease that is spread from one infected person to another through having sex, giving birth and by any

other behavior where an infected person's blood, semen, vaginal juices or breast milk enters another person's body.

HIV attacks the body defenses against diseases, weakening a person's ability to fight off infections and diseases. Often this takes years to occur, so many people live years with HIV completely unaware that they are infected. One of the reasons that it has spread so rapidly is because infected people often look and feel well. When the defenses are exhausted the person becomes ill and dies from another illness (very frequently TB). When a person with untreated HIV gets ill with untreated TB they often cannot survive very long.

There is no vaccination or cure for HIV. Treatment that prolongs the healthy stage of HIV is available in many areas of the world, but in countries without free health care, these drugs are often too expensive for most people.

Sexual transmission of HIV is preventable with the correct use of a new, quality latex condom with every act of sexual intercourse. While, condoms are available free in some parts of the world, they are either too expensive or not always available in most places. Male resistance to condom use has been responsible for the transmission of HIV to women. All women should be encouraged to insist on condom use even if they have only one sexual partner. HIV and other sexually transmitted diseases reveal gender power inequities all over the world. Women in poor rural communities, including artisanal mining communities, experience gender power inequities that are created and augmented by economic, social, and gender role expectations and by traditions.

Gestational (mother to baby) HIV is preventable only if there is a supply of HIV medicine and good birthing care available to the pregnant HIV positive woman. Blood to blood HIV transmission is preventable through avoidance of reusing needles and other instruments that break one person's skin and then another person's, and through testing of blood products for transmission in hospitals.

Malnutrition

In much of the world, most people eat one main low-cost food with almost every meal. Depending on the region, this may be maize, millet, rice, wheat, cassava, sorghum, banana, potato or breadfruit. This main food provides most of the body's needs. Other foods are needed to maintain health in addition, and this is particularly important for growing children, pregnant women and the elderly. These other foods include vegetable oils, sugars, vegetables, fruits, seeds, nuts, beans, milk, eggs, fish and meat, which provide protein, energy and

protective factors. These additional foods become scarce and too expensive in times of extreme poverty, population movement and drought.

When these foods are available the male adults need to be aware of their own resistance to malnutrition compared to other members of the family and community and prioritize appropriately. Unfortunately this is often not understood early enough, and children die at a disproportionate rate. It is important for us all to remember how vulnerable to malnutrition a large percent of the human population is when there is no food reserve.

Local nutrition programs commonly offer lessons about food groups, meal planning around the area's staple foods and appropriate crops to grow to supplement diets.

Conclusion

Members of artisanal mining communities should be encouraged to cooperate with government staff, health care workers or NGOs who are asking for details of sick people or who are offering support for mosquito elimination, water and sanitation, HIV prevention, family planning and child nutrition programs. If available locally, individuals should know where to obtain condoms, health care, mining safety equipment, and information and support to establish safe water systems and sanitation.

It is important to consider how illness can stress a child with malnutrition to the point of death, how malaria affects a pregnant woman, and how getting infected with TB can hasten the death of a young man with HIV. In fact it is critical to understand how all of these health issues interplay and increase the stress and decrease the strength of individuals and whole communities in order to be successful working in artisanal mining communities.

Basic knowledge for miners

- Malaria
    - Malaria is a disease carried by mosquitoes that kills 2 million/a worldwide
    - Malaria is preventable
    - **Preventing malaria involves whole communities working together to eliminate breeding places for mosquitoes**
    - Prevention also usually involves netting over windows, doors and beds

  - Children, pregnant women and the elderly are the most likely to die from malaria
  - Treatment must be prompt and complete
  - Drug prescriptions must be followed exactly
- Tuberculosis
  - Only 5 – 10% of those infected with TB become ill
  - If left untreated, each of these people infect 10-15 people each year
- HIV AIDS
  - Human Immunodeficiency Virus (HIV AIDS) is a disease that is transmitted by sexual contact and blood
  - 6 thousand people die from HIV AIDS everyday
  - 8,200 people are infected with HIV everyday
  - HIV attacks the immune system, the body's defenses against other diseases
  - There is no vaccination against HIV
  - **Prevention is the best option and involves consistent, correct use of condoms during sexual intercourse**
  - Treatment during pregnancy can reduce the incidence of transmission from infected mother to baby
  - Treatment for HIV is expensive and not available to everyone infected
- Malnutrition
  - Malnutrition kills 6 million children under the age of 5 each year
  - Of the 800,000,000 people who are hungry each day 300,000,000 are children
  - Most of these children suffer long-term malnourishment and micronutrient deficiency

Chapter 10
Clean Water and Sanitation

Why clean water and sanitation are important

"Safe water supply and adequate sanitation to protect health are among the basic human rights. Ensuring their availability would contribute immeasurably to health and productivity for development"

Dr. Gro Harlem Bruntland, Director-General, WHO – World Health Organization.

About 1.1 billion people around the world lack access to safe drinking water, and 2.6 billion people lack sanitation services. The UN Millennium Development goals aims to insure delivery of sanitation to 1.75 billion people by the year 2015. Inadequate or complete lack of sanitation services leads to more than 1.5 billion cases of diarrhea every year, causing over 4 million deaths, most of whom are children under the age of 5 years. Poor sanitation also leads to 1 billion roundworm and 1 billion hookworm infections (70,000 deaths) and 200 million cases of shistosomiasis (200,000 deaths).

The health status of artisanal mining families around the world is generally very poor. In artisanal mining communities, access to health care is minimal or absent, sanitation is lacking, and while the income from gold mining leads to better quality of life, mercury intoxication significantly affects miners' health. In many instances, programs to reduce mercury exposure of mining families should address basic community health needs like water and sanitation at the same time as introducing safer and more effective mineral processing techniques. Reducing the stresses that mining families face--legal and financial, as well as health—will make it easier for miners to accept new technologies that reduce their exposure to mercury.

A key health need of mining communities is often the lack of clean water and appropriate sanitation. People require sanitary toilets that isolate excreta safely in pits, in addition to a minimum of 30 to 50 liters of clean water per person per day, in order to stop excreta transmitted infections and parasites that lock mining families into un-ending cycles of intestinal diseases that cause poor absorption of nutrition.

There are a number of proven, very low-cost technologies capable of delivering clean water and preventing the spread of disease through control of excreta and wastewater disposal. Water can be sourced from groundwater wells, surface water, or harvested rainwater. Contaminated water can be made safe to drink by

removing pathogens through sedimentation, filtration, and subsequent disinfection. Water supply solutions can be centralized (e.g., a community water well) or individual (e.g., low cost household sand biofilters).

Simple provision of water supply and sanitation alone is not enough—hygiene promotion is essential. In Zimbabwe's successful sanitation program in the 1980s for example, Ministry of Health extension workers were trained in latrine construction methods, and films demonstrating latrine construction where shown to 1.5 million rural people annually; in schools, children built models of various types of latrines as part of the grade 6 curriculum.

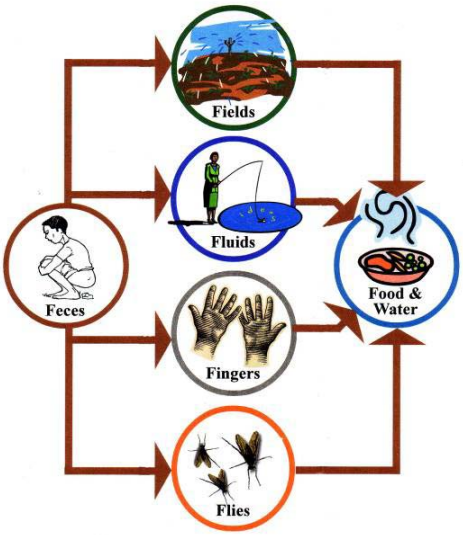

Fig.10.1 - Pathways of fecal contamination of food and water. *(Illustration L. Pevick)*

Changing sanitation practice is a complex social endeavor. There is no universal technical solution or approach to education. Because cultural and social factors vary from region to region, trainers must develop an understanding of how local communities and households function within their society, and of the factors promote and limit change. (This of course applies equally to the introduction of mineral processing technologies.) Factors that control the ability of communities to change sanitation practice include the nature of local leadership and authority, cultural beliefs and defecation practices, and gender roles that influence hygiene practice and determine who is responsible for water supplies, family health and children's defecation behavior.

Low cost clean water options.

Shallow, open wells and surface water are often contaminated in poor rural communities. Deep boreholes that tap confined aquifers are more likely to yield clean water, but deep boreholes are often too expensive and clean water from deep wells can be easily contaminated while being carried to and during storage in peoples homes. In addition, pumping and distribution systems for boreholes are costly to maintain.

Using a simple sand filter in the home can insure that domestic water is safe. Almost 500,000 people are using BioSand filters designed by the Centre for Affordable Water and Sanitation Technology (CAWST, www.cawst.org). Sand and gravel in 40 x 40 x 100 cm concrete boxes utilized the same principles used in city water purification systems world wide to remove pathogens--the sand traps the large pathogens and they die. Some smaller bacteria and viruses pass through the filter, so disinfection with household chlorine bleach or UV light from the sunshine (put the filtered water in recycled 1-2 liter clear plastic bottles on their side in the sunlight for 6 to 12 hours (http://www.sodis.ch) is recommended.

Depending on the availability of materials and the cost of labor, these filters can be manufactured for $US 10 - 40, and last for decades. Costs can be greatly reduced when community members learn how to make these filters themselves. Those who learn how to make these filters can start micro businesses and earn money selling them to their neighbors.

Fig. 10.2 – BioSand filter in Guatemala

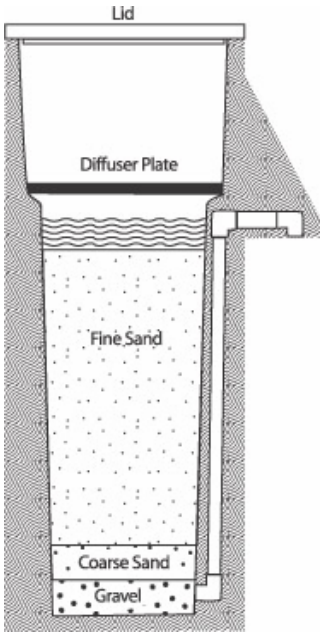

Fig. 10.3 - Schematic of CAWST's BioSand filter.

Low-cost sanitation options

Open defecation, either indiscriminate or in specific locations, is widely practiced around the world, but this practice leads to transmission of disease and the spread of the larvae of intestinal worms through flies, human and animal contact, and contaminated water. Open defecation should not be allowed in villages, and sanitation methods that confine excreta should be encouraged. A slightly better option than open defecation is to use the small pit or "cat method"; next best is a simple pit latrine, but even more effective are ventilated pit latrines which dramatically limit the access to excreta by flies which spread the pathogens.

People sometimes practice the "cat method" or digging small holes and covering their feces with soil; alternately, they dig small 30 cm deep pits which they use for a few weeks, progressively covering the feces with the excavated soil. While the bacteria in the topsoil lead to rapid decomposition of the excreta, large numbers of flies are attracted by the smell, and hookworm larvae can spread in the soil around the holes and penetrate the soles of feet of the users.

Simple pit latrines use a squat hole in a slab placed over a pit of 2 or more meters in depth. The squat hole can be sheltered by a small hut, or can be in the open-air surrounded by thatched screen enclosures for privacy. The slab is usually raised above the surrounding ground level to keep surface water from running into the pit; the slab is sometimes elevated in regions where the groundwater is near the surface. The pit itself should be lined if likely to collapse due to soil instability. Pit latrines are low-cost, easy to build, and the operation principals are easy to understand; however they can smell considerably, and unless the squat hole is tightly covered, flies (and mosquitoes if the pit is wet) are attracted. Simple pit latrines can also utilize 40 cm diameter by 8 meter deep boreholes excavated by an auger. These boreholes can be excavated relatively quickly, but have a short life due to their relatively small volume. Because of their depth, borehole latrine pits increase the risk of contaminating groundwater.

Fig. 10.4 - Open defecation leads to spread of disease and should be discouraged whenever possible. *(Illustration L. Pevick)*

Ventilated pit latrines were a Zimbabwean invention in the early 1970s. Sometimes these latrines are called "Ventilated Improved Pit" (VIP) latrines, or "Blair toilets" owing to their genesis at the Blair Research Institute near Harare. VIPs represent a substantial improvement over a simple pit latrine because odor and fly nuisance is dramatically lowered by a pipe that ventilates the pit (tests have shown that ventilated latrines have only about 1% of the flies found in simple unventilated latrines). The vent pipe is heated by solar radiation which creates an updraft, pulling air through the squat hole and exhausting the smell above the latrine enclosure. Flies are attracted to the exhaust odor at the top of the vent pipe, but are prevented from entering by a screen. Flies are also attracted by light, so the enclosure is kept as dark as practical so that any flies that enter through the squat hole try to escape toward the light at the top of the pipe--their exit is blocked by the screen at the top of the vent pipe where they eventually die and fall back into the pit.

Other more complex and costly sanitation options include pour-flush latrines, composting toilets, septic tanks, aqua-privies, and pump-able vaults and cesspits.

The World Health Organization has published a comprehensive guide to the complete spectrum of appropriate sanitation options for the developing world, "A guide to the development of on-site Sanitation" building on the work of Peter Morgan and Duncan Mara (e.g., "Ventilated improved Pit Latrines in Zimbabwe"). These papers provide complete engineering specifications and drawings for site selection, safe pit excavation, superstructure construction, and latrine maintenance, and should be studied by trainers who wish to design a sanitation program for ASM communities. Both papers are available on the Internet and are referenced at the end of this chapter. ASM trainers can often find experienced water and sanitation experts in local ministries of health and environment.

VIPs are a good solution for rural and peri-urban sanitation needs. VIPs have been widely accepted in the developing world. In Zimbabwe, for example, more than 500,000 have been built over the last 30 years, owing to the effective promotion and hygiene education by the Ministry of Health's extension staff.

Where to put latrines

Care has to be taken when locating latrines near drinking water sources. Effluent can migrate from latrine pits and contaminate water. Pathogens can be carried some distance in the groundwater, especially in fractured rocks during high rainfall events. Soil can filter large protozoa and some bacteria; smaller organisms are removed largely by adsorption to the surface of soil particles, a mechanism that is favored by slow flow rates in low pH and clay soil. Contaminant flow in groundwater is variable and depends on local hydrogeological conditions.

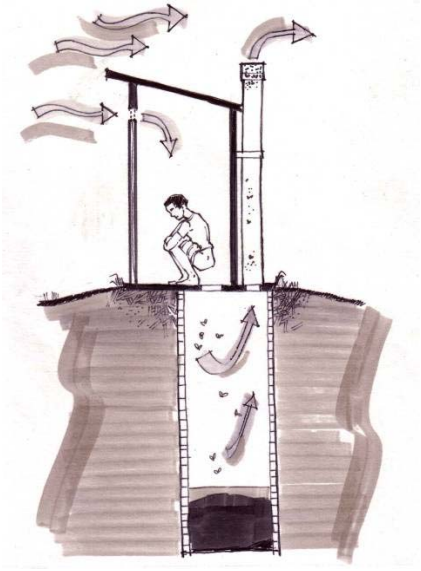

Fig. 10.5 - Ventilated pit latrines (VIP) are host to only 1% of the flies that are attracted to simple pit latrines. *(Illustration L. Pevick)*

Pit design

Sludge accumulates at a surprisingly low rate. In Zimbabwe, for example, sludge accumulation rarely exceeds 0.02 m^3 per year/person when the latrine is washed down regularly and where paper is used for anal cleaning. Sludge accumulates at about twice this rate when the pit is dry and where solid objects are used for anal cleaning. A wet 1.5 meter diameter pit 3 meters deep can serve a family of 6 people for 35 years.

VIP pits are typically 1.5 to 1.75 meters in diameter, and about 3 meters deep. Partial or full cement mortar pit linings prevent collapse and access by insects and rodents. The hole is covered with slightly larger diameter, 7.5 cm thick slab that is usually pre-cast on site. Superstructures (huts) can be rectangular or spiral shaped (spirals that open towards prevailing winds scoop the air and push it into the squat hole, keeping odors out of the superstructure; but it should be kept in mind that the direction of the spiral—right- or left-handed—can have negative meanings in some cultures. Where no doors are used, screens or fences can be positioned to insure privacy.

Where mosquitoes are a problem due to high groundwater levels causing flooding of the pits, periodically covering the surface of the water with 5 mm polystyrene balls makes it hard for mosquitoes to breed.

Pit excavation

Loose ground is liable to collapse, either while the pit is being dug (endangering the excavator) or later while the latrine is in use. A safe way to excavate a pit is to use a *caissoning* method where pre-cast concrete rings are laid one on top of another as a worker inside the rings digs soil from underneath the bottom edge of the ring—as the digging proceeds, the stack of rings pushes itself downward into the soil, protecting the worker. Ferro cement reinforcing linings can be constructed by pushing concrete mortar into several layers of chicken wire which is stapled into the pit walls.

Floor slab

The 6.5-7.5 cm concrete floor slab should be reinforced with chicken wire (about 4 layers), or scrap steel reinforcing bars spaced 15-20 cm apart. Holes are left in the slab casting to accommodate the squat hole and vent pipe, and footrests are added later. The surface of the slab is toweled smooth, and the area near the squat hole is sloped slightly inward.

Slabs can also be made of timbers covered with concrete or soil (note that soil floors in latrines can lead to hookworm infection). Rotting of the wood supports can lead to weakening and collapse, as do termites and other insects. Indeed, in some places people tend not to use latrines with wooden floors for fear of falling into the pit.

Mixing the cement for the slab is not a trivial matter. A rule of thumb is to keep the concrete mixture as dry as possible, but keep the cast slab as wet as possible while curing. If kept moist while curing for 3 days, it will achieve 80% of its potential strength, but if allowed to cure moist for 7 days, it will achieve maximum strength. Slabs are usually cast with concrete made of 4 parts aggregate (1-2 cm), 2 parts builders sand, 1 part cement and 0.5 parts water. Use a little more water when the aggregate is very dry in arid climates.

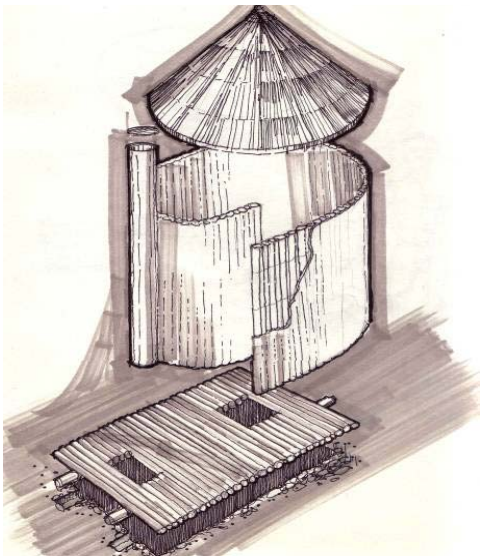

Fig. 10.6 - A spiral shaped, low-cost mud, wattle and thatch VIP on a wooden platform. *(Illustration L. Pevick)*

Latrine structure and vent

The pit is ventilated by a pipe or brick chimney which is attached to the outside of the superstructure, and facing the equator in order to maximize the updraft by maximizing exposure to solar radiation. Vent pipes can be made from local reeds, wire and cement mortar. Flies are attracted to both odor and light. The vent pipe's suction insures that as little odor as possible emanates from the squat hole. If a door is used, it is necessary to provide an air intake hole in the superstructure to enable the suction effect (usually this is placed above the door). Keeping the superstructure as dark as possible insures that flies will be trapped when they try to escape toward the light at the top of the stack. Cobwebs inside the stack

from spiders feasting on the trapped flies can block airflow, and should be flushed periodically with a bucket of water.

The superstructure can be built with bricks, or with mud, wattle and thatch. If thatch is used, it should be thick enough to keep the inside suitably dark. The vent pipe should be about 15 cm inside diameter if made of smooth material like PVC pipe, or at least 23 cm diameter if made out of rough materials like bricks. A 1.2 to 1.5 mm mesh fly screen should be wrapped over the top of the pipe. Because the vapors from the pit are slightly corrosive, stainless steel and aluminum last much longer than galvanized or plastic screens (which are destroyed by sunlight).

Basic knowledge for miners

- The international community has placed high priority on helping communities achieve clean water and basic sanitation. Communities should know this and pressure their government and NGOs for water and sanitation assistance
- 2.6 billion people in the world lack sanitation services
- Lack of sanitation services leads to more than 1.5 billion cases of diarrhea every year causing over 4 million deaths, most of whom are children under the age of 5 years.
- Poor sanitation also leads to 1 billion roundworm and 1 billion hookworm infections (70,000 deaths) and 200 million cases of shistosomiasis (200,000 deaths) per year
- Communities can implement simple programs themselves
    - Historical gender roles and cultural resistances need to be acknowledged
- Domestic sand water filters are cheap, effective and last for decades
    - BioSand filters remove all large pathogens (worms and parasites), and about 95% of bacteria
    - Filtered water can be easily disinfected with chlorine bleach or sunlight
- Ventilated pit latrines (VIPs) are almost completely nuisance free—no smell, flies or mosquitoes
    - VIPs are long lasting and inexpensive
    - Easy to build

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Chapter 11
The Rising Value of Gold

For centuries, gold has been the world's most recognizable form of economic exchange. The value placed on gold as a symbol for wealth has made gold mining, especially artisanal gold mining, one of the oldest, most reliable extractive industries. But in 1944, following the Second World War, the representatives of 44 nations gathering at Bretton Woods, New Hampshire, fixed the price of gold at $35 per troy ounce (31.1 g). This system tied the value of gold to the U.S. dollar, made it illegal in many places for private citizens to own gold, and put a cap on the amount of gold central banks were permitted to hold.

When the Bretton Woods system eventually collapsed in the middle of the 1970's, many people expected there would be an immediate rush to produce and horde gold. In fact, this rush did not happen until the 1980's when the great gold rush of Brazil exposed the newfound importance on gold. In periods of economic uncertainty, central banks and entrepreneurs still revert to gold to hedge their bets against the fall of paper currency. And in September 2001, even as people were just beginning to absorb the meaning of the fall of the World Trade Towers, the whispering on the floor of the stock exchanges had already turned to a shout: Buy gold.

Since then, the international price for gold has more than doubled. Gold is currently exchanged on the international market for more than $US 600 an ounce (31.1 grams), and some analysts are predicting the price will continue to climb for several more years. While predicting the price of gold is difficult, what is known is that central banks in Russia, China, and other powerful countries are again buying up gold bullion, in some cases doubling their current reserves.

Meanwhile, consumer demand for gold is also at an all time high. In countries like India and China, where there is high population growth and an increasing middle-class, the ornamental value of gold is creating high demand for more gold production and manufacturing of jewelry.

The rise and fall of the value of gold does have some impact on the overall number of artisanal gold miners. Yet, because starting out in artisanal gold mining is relatively inexpensive, even when low international gold prices make large-scale mining uneconomic, artisanal gold mining tends to persist. But now

the rising price of gold is creating more demand for new sources, and artisanal gold mining is expanding faster than at any time in history.

Artisanal gold miners produce roughly one-quarter of the world's primary gold. There are thousands of remote artisanal gold mining communities spread across 55 countries in Latin America, Africa, and Asia. As many as 15 million people are thought to be mining gold artisanally, and 80-100 million people rely on the economic matrix of small-scale gold production.

While the gold rush phenomenon is global, artisanal gold mining practices and experiences vary widely from place to place. Miners use a broad range of mining methods, come from dozens of language groups, and have different kinds of social, economic, and political arrangements. There are full- and part-time miners, some relying on gold as their only source of revenue, and others using it as supplementary income during periods of economic drought. Levels of organization also vary widely, from permanent communities with established labor organizations, mining cooperatives, and legal status, to migratory groups and itinerant workers operating illegally as part of the world's "informal" economy.

The high gold price is one of the reasons for the growth of artisanal mining, but in the 21st Century artisanal gold rush started well before the price of gold increased. It is predominantly a developing world activity linked closely to poverty. On average, an artisanal gold miner earns about two to three dollars a day – which is much more than what somebody living in extreme poverty would otherwise earn.

Part of the appeal of artisanal gold mining remains the prospect of striking it rich. Indeed, the idea of a gold rush still evokes images of prospectors plucking plum sized nuggets from the bank of the river and retiring on the profits, though even in the great 19th century gold rushes stories of the great find could be profoundly exaggerated. Today in gold rich regions it is still common to hear rumors circulating about someone who did hit the "mother lode". When it happens a "shout" goes out, and news spreads rapidly by word of mouth. Usually the value of the discovery fluctuates dramatically and depends on the level of geological information available and if the miners have the mineral claims in good legal situation. Junior exploration companies, for example from US, Canada, Australia, are well-known for negotiating prospects with artisanal miners. When the company is serious, a miner can share the risks of finding more gold with the company. If a miner wants to negotiate his/her legal mineral title with a mining company, he/she must understand that the company will not

pay for a claim just based on what the miner asks or "supposes" that it is underground. The company needs geological proof to establish a gold reserve. This implies in geological studies, geochemistry, geophysics, drilling and sometimes, metallurgical tests to see if the gold is easily extracted by cyanidation (which is the main process used by major companies). Unfortunately, most artisanal miners do not have mineral titles or, when they have, they are not in good shape. It is also common to see miners that want to negotiate their titles with companies but they want all money up front because they are bankrupted or they want to get out of the mining life. Very rarely mining companies accept this kind of deal.

In fact, today's artisanal gold miners are one of the most marginalized, impoverished, and vulnerable groups of people, and high international prices are not always reflected by substantially higher profits for artisanal gold producers. The core development issues identified by the United Nations Millennium Goals are critical for gold mining communities. Gold miners operate in a political and legal no-man's land where mineral rights and land title are often poorly defined, poorly enforced, or both. Disease is epidemic: In extreme cases, seventy-five percent of people in artisanal gold mining communities are HIV positive. Toxic chemicals – especially mercury – are used in ways no organized labor movement would accept for industrial workers, or any responsible government should permit given what is known about the health effects from mercury exposure. Malaria and typhoid are widespread, as are malnutrition, child labor, gender discrimination, and lack of basic sanitation services and access to clean water.

Yet, for many millions of miners, gold is the quickest, and in many cases the only locally available cash crop. Throughout the world, there are still literally billions of people who lack the capital, the trade networks, and the property rights to be active participants in the cash economy. Gold is one of the few commodities requiring little investment in infrastructure. Its market value is high enough that if a trader develops enough reliable producers he can afford the expense of flying into remote areas to buy raw gold. Not so for the artisanal gold producer, for whom the expense of leaving the bush would immediately wipe out earnings from his meager grams of gold. Meanwhile, this system works out well for governments which benefit by taxing the export of the gold without having to invest anything in rural infrastructure.

In truth, there are two gold production economies: One operated by large companies with the resources to invest in the equipment, technology, and personnel to process enough gold-bearing ores to earn billions in profit. And a

second economy in which local producers are trapped by poverty that pushes them towards mining without offering any opportunity for capital development.

To overcome this poverty cycle, the local price for artisanally produced gold needs to be fixed at a higher rate. Unfortunately, the present structure of the gold supply chain does not allow for this. Currently, all gold – artisanal and industrial – eventually ends up at the same handful of refineries around the world. Artisanal miners lose profit by not having direct access to these refineries. One answer to this dilemma may be, as the Government of Tanzania recently demonstrated, to establish small-scale refineries dedicated to purchasing and processing gold only from artisanal producers. Another solution could be to create value added products or certified small-batch commodities similar to ongoing efforts in the agricultural sector to create Fair Trade coffee, rice, chocolate, and cotton industries. In these schemes, additional costs are passed on to consumers who pay premium prices on the assurance this premium finances progressive social and environmental development for local producers.

For artisanal miners, even as gold's value is booming, profit is not distributed equitably to local producers and the natural capital of local communities is being diminished. Rather than financing sustainable community development, higher gold production can strip the land bare of its mineral wealth and replace it with contaminated ecosystems and social deprivation. For artisanal gold mining to lead to greater prosperity and less poverty, artisanal gold communities need organizational tools to deliver their gold more directly to market. In turn, these additional earnings need to be transformed into social capital – mining, environmental and primary school education, and health care and economic diversification – to support the long-term well being of artisanal gold mining communities.

Basic knowledge for miners

- The price of gold changes every day on the international gold market.
- Gold buyers pay miners less than international rates because
    - they want to make a profit to compensate for the risks they take
    - miners' gold is not pure
- Miners can increase the amount of money they receive for their gold if they
    - Develop their own collective marketing systems in order to share the marketing risks and benefits
    - Add value to their gold
        - Make jewelry

    - Certify that their gold is produced in the best way they can by demonstrating good social and environmental practices—communities can work with NGOs to establish Fair Trade standards that are appropriate to local condition
- If miners want to negotiate their legal mineral titles with mining companies, they must understand that the companies will not pay them based on what the miners ask. The companies need geological evidence to establish a gold reserve. This is mandatory in all Stock Exchanges. In this case miners must be prepared to make an association with the companies and share the risks of the geological exploration.

Green, T., 1968. The World of Gold: *The History, the Lure, and the Power of Man's Most Precious Metal.* Simon and Schuster, New York, p.99.

Kisembo, P., 2005. Tanzania embarks on value addition to gold exports. The Guardian, Dec. 2, 2005