WATER FOR EVERYBODY

A Selection of Appropriate Technologies
to be used for Drinkable Water
EMAS

Popular autodidactic Training

Supporting text to EMAS films, for all those who wish to improve drinkable water, micro irrigation or basic sanitation.

Wolfgang Buchner
5th edition, 2006

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<u>WATER FOR EVERYBODY</u>

<u>Introduction for the user of these texts</u>
The ESCUELA MOVIL AGUAS Y SANEAMIENTO BASICO (EMAS) was created with the eagerness of achieving the necessary supply of drinkable water, and water for micro irrigation in rural and sub urban areas. Its founder and academic director is Mr. Wolfgang Eloy Buchner. EMAS receives support from a group of volunteers from Munich, Germany. Although EMAS does not finance projects, it can give support - as a partner - to local initiatives by means of practical and theoretical training through the "learning - performing" method. Upon request, EMAS performs an advisory role in Latin America, Africa and Asia.

<u>The EMAS concept is based on:</u>
A variety of simple technologies such as manual drilling of deep wells, manual pumps built by users themselves, small impounding from springs, ferro cement tanks, sanitary installations and much more. The user learns these simple technologies, and therefore he can maintain and reproduce them himself. A very important factor in this concept is the training of drillers who are suppliers of drinkable water at local level. For many years, these professionals of rural areas offer their services to users and at the same time they transmit their skills to other students.

The purpose of this book is to make easier for sanitary technicians and drillers, decisions regarding the best solution. These texts are based on experiences obtained on site during many years of labor and investigation. EMAS authorizes to copy this text, but those who do so are requested to inform as regards their purpose.

I also wish to express my deep gratitude to my wife and children for understanding my absence from our home during those long periods when I have to stay at training, prospecting and testing sites.

Wolfgang Eligius Buchner, Author.

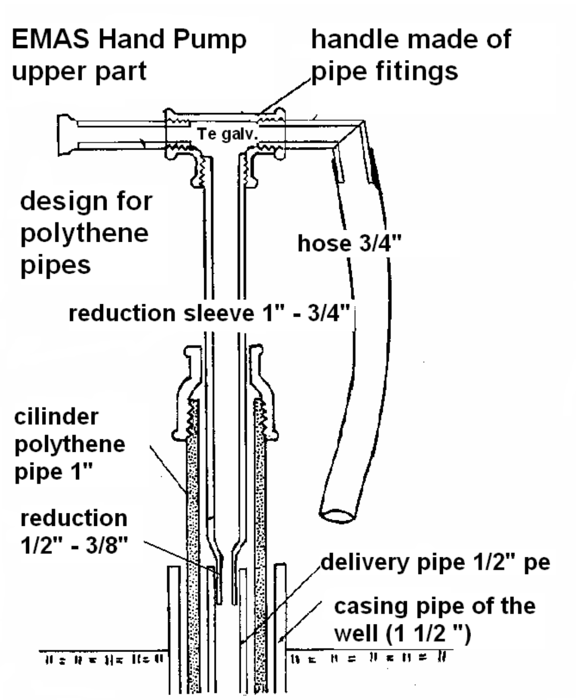
<u>Patent of the "Alternative System for Drinkable Water" :</u>
The drilling system and FLEXI pumps has been patented in Bolivia with Number 5221, dated March 18, 1996 in the name of Wolfgang E. Buchner.
As owner of this patent and with no charge, I grant my express authorization for the use of this technology to help the needy, to any unipersonal driller (rural, artisan micro undertaking) who has learnt the techniques through EMAS, as well as with already trained driller master workmen.

The price of the components (wells, pumps, filters, etc.) will be according to the regional costs in each country. Usually they consist of : 1/3 = cost of materials; 1/3 = cost of : transport, labor, abrasion; and 1/3 = cost to cover failures, or for new investments.

EMAS pump

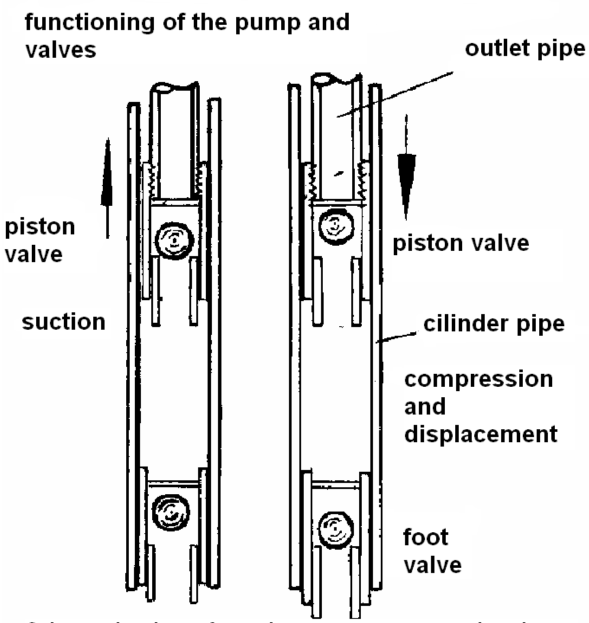
EMAS FLEXI pumps are also known as OPS - FLEXI pumps, because years ago EMAS granted a free license of its patent to the Panamerican and World Health Organization. These are manual pumps that the user easily learns to build, since they are made of PVC piping or of Polyethylene. The pressure or the water volume to be pumped can be determined varying the diameter of the cylinder (using pipes of a larger or smaller diameter). All EMAS pumps have an outlet pressure that allows pumping up to 60 meters height, or 2 Km horizontally. The flow varies between 0.2 and 1 liter per pumping, according to the pattern.
In Bolivia, the cost of a 12 meter length standard pump is of approximately 20 Euros.

EMAS pumps are fit for multiple use. They are set up in wells drilled with a reduced diameter (EMAS system), engine operated drilled wells, hand excavated wells, cisterns, micro impounding and pumping plants. Their main advantage is that the user himself can build them and reproduce them with materials from the hardware store and at low cost. Once the well is clean and activated, the pump is installed.
EMAS has developed this type of manual pump which is cheap, simple in its construction and maintenance and, most of all, it fits in a narrow well of only 1 1/2" diameter (EMAS well).



The standard type pump comprises two PVC rigid pipes, or two polyethylene hoses. The pipe with the largest diameter, 1 inch, forms the cylinder, and the other one, 1/2 inch, operates at the same time as connecting rod and outlet pipe. Its performance is similar to the one of a piston pump, with the only difference that water is ejected through the connecting rod itself. The handle grip or holder consists of a T with two lateral nipples, one of them blind, and the other one with an open outlet whereby water flows. The 1 meter metallic tube goes in and out from the well, and performs as a friction fitting with the cylinder guide. At its lower end, it is connected with the outlet pipe or the connecting rod. The connecting rod ends at the bottom of the pump, with the piston valve. The connecting rod, moved through the handle grip, makes the piston valve go up and down. When the piston goes down, the volume at the cylinder decreases and the water from the cylinder is ejected upwards by the connecting rod; finally it is ejected through the outlet nipple. The cylinder pipe goes up to the surface; in its upper part it has a metallic guide, usually a 1" galvanized iron nipple, or a 1" - 3/4" reduction coupling as a piece for guide and friction. The standing, or intake valve is attached at the lower end.

Pumping can reach a pressure up to 5 bars, which allows direct pumping from underground water up to an elevated reservoir. At the same time the pump also allows the extraction of water from a dynamic level of 40 meters depth (1" cylinder). The flow of each pumping depends on the height of the holder, but generally 0,3 and 0,5 liters per pumping are obtained, which means from 15 to 30 liters per minute (1" pump). High pressure EMAS pumps can elevate water up to 100 meters. However, the diameter of their cylinder is quite reduced. The opposite occurs with cylinders larger than one inch. The flow increases, but the pressure decreases.



Going up the piston, foot valve opens, water enters into the cilinder, cilinder valve is closed. Moving down the piston, foot valve shuts, water is desplaced from the cilinder, piston valve opens and water is delivered.

Valves are built with 3/4" screw threaded type PVC pipes (standard valve) and 1/2" PVC pipes (universal valve) with a small crystal ball inside. To obtain more compression and prevent loss of flow, rubber rings are provided to the piston valve. In case of abrasion or deterioration, the valves or rubber rings can be easily replaced. The same thing occurs when PVC adapters (box and pin) are weld, in order to build the valves.

The pump looks like one single pipe with an iron holder. The pump fits exactly into the well drilled with the EMAS system, of l l/2" diameter. The pump is submerged into the well, according to the dynamic level of the well, and about 3m deeper. The measure of the EMAS pump most commonly used is between 6 and 12 meters, but there are wells that need as much as 40 meter pumps.

For remote pumping, or pumping to an elevated site, a rubber hose, from 1 to 2 meters length is attached to the outlet nipple, in order to compensate upward and downward motions. The other end of the hose is connected with the outlet line to the elevated reservoir. To transform the pulsating stream in a continuous stream, and thus alleviate the remote pumping, set up an air chamber (please see the module "water for all places-hydraulic ram" .

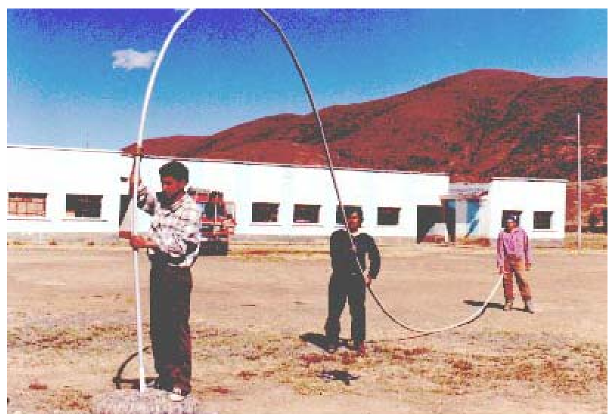
Maintaining the pump

The correct maintenance of a well and an EMAS pump is most important for a good quality of the water and long lasting of the pump. It is also advisable not to pump always in the same position of the holder; by varying it, the abrasion of the outlet valve is distributed throughout its surface, thus increasing the valve life span.

When the pressure of the valve decreases, it is because the gasket is worn out. Striking its base line when subject to pressure, or removing the screw thread, readjust it several times. Then change the rubber gasket; you can make one by cutting a small piece from a tire. The outlet valve has a life span of about 500.000 liters. Then it has to be changed with a new one. In Bolivia its price is equivalent to US$ 1,50. This work can be performed by the local driller or by the user himself.

The EMAS pump allows to change 3 - 4 valves. Then, also the plastic pipes are worn out. When using a pump made of PVC pipes, first the couplings are worn out until the bell is pierced. The problem is solved cutting the defective bell and coupling it anew. To avoid water from flowing between the guide and the holder, when pumping with pressure, drill a 1 cm2 hole approximately 1,5 mt below the holder, in the cylinder pipe. Thus, water returns to the well.

When pumping, do not strike on the metallic guide with the T. The plastic tube may suffer damage, or it may slide from the layer that fastens the cylinder (1" pipe) and all the cylinder may fall into the well. If the pump cylinder has fallen, ask for help from the driller. With a screw thread at the sharp end, you may recover the pump. Do not use sticks or other things.



It is important for the rubber between the well and the pump to be always in good conditions; otherwise the risk exists for the cylinder to unfasten, and be the cause of trouble. For the rubber not to break up, burnt by the sun, it is advisable to envelop with a cloth, and tie it with thread or wire.

In case the intake valve is defective, the pump may continue to operate provisionally, pumping skillfully, quickly accelerating the pipe upwards and suddenly stopping (reverse hydraulic ram). If the outlet valve fails, pumping can also take place in an emergency, removing all the outlet pipe and using the cylinder as a reverse hydraulic ram.

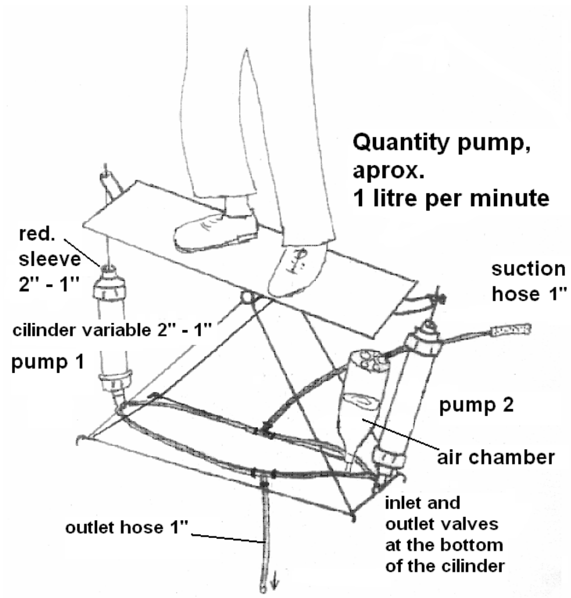
When removing and introducing lengthy pumps from/to deep wells, the risk exists to break the pipes. In order to avoid damages, arch the pump as shown in the photograph, bending it.

Many people wish to protect their pump from undue use. If you wish to put a padlock for the pump, weld a ring to the guide metallic pipe, and another ring to the T holder (photograph) .

Pedal adapted EMAS pumps

There are different types of pedal operated pumps, most of all for their use in irrigation. Pedal work has the advantage of being less tiring than the manual form, since the muscular structure of the legs is stronger than the one of the arms.

Pedal pumping is similar to a children's seesaw. Differing from other patterns, EMAS pumps have the advantage of conveying water from a fairly good distance, or to elevate it to a height up to 40 meters. Pumps can be built for flow or height, merely varying the diameter of the cylinder. The EMAS pedal system always has two twin pumps operated by a lever with equal arms. When one side goes up, the other side goes down. When going up, the cylinder is filled with water and at the same time the other cylinder is emptied, because its piston goes down. Presently there are three different constructive types.

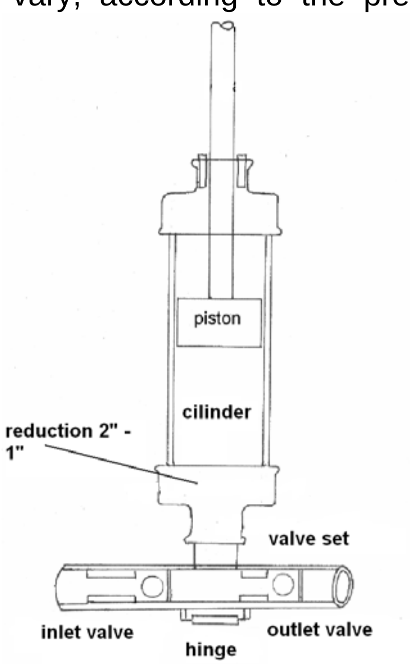


1 . lake or river pumping

For this pumping, a compact and portable mechanism is used.

The valves are made of galvanized pipes and their accessories, very similar to the ones of the mud pump for drilling wells.

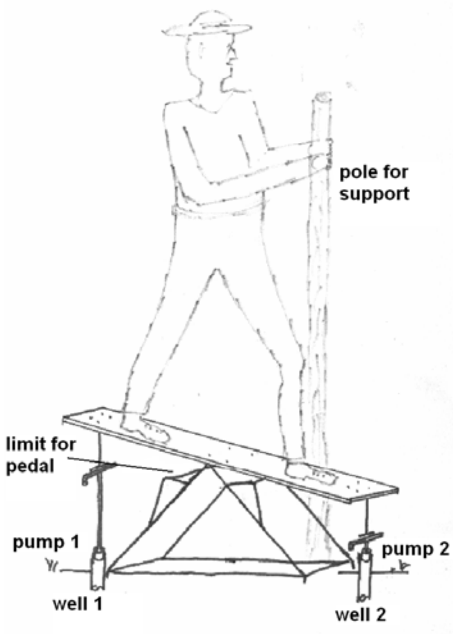
Both valves are located at the same level, at the lower part of the pump, and they form the valve head. On its upper part it has a 1 inch screw thread, to which the reduction coupling for the plastic cylinder pipe is screw threaded. The advantage of a PVC cylinder is that it is more polished, and therefore it has much less friction than a steel pipe. The diameter of the cylinder may vary, according to the pressure needed. Usually diameters from 1,5 to 2 inches are used for irrigation. The cylinder is a pipe of about 40 cm length, with a screw thread on both sides. A reduction coupling connects it with the head. On its upper part it has another reduction coupling which operates as a guide for the connecting rod. The piston is simply a piece of galvanized pipe, plugged on its lower side. If it has been given a precise measure, it needs no gasket, or else it can carry a gasket made of tire or cloth. The connecting rod has two hinges that allow to compensate the motion, and are fastened on the pedal board. All the framework is welded and made of 1/2 inch iron for construction.



2 . pumping by twin wells drilled

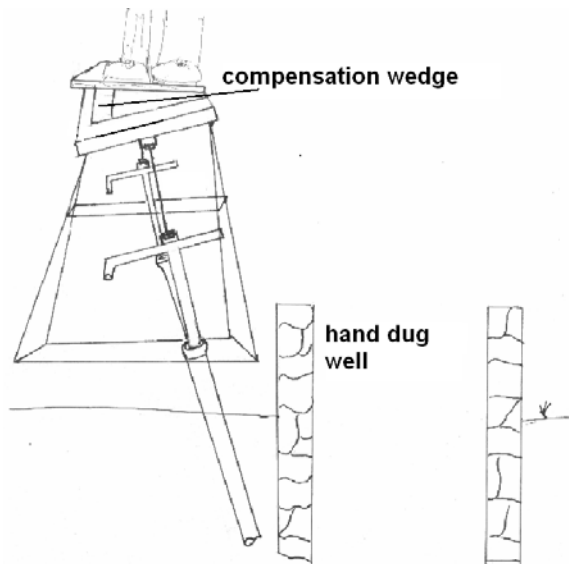
If the subsoil has good quality aquifers and if the land can be drilled, you can choose the twin wells' system. With the

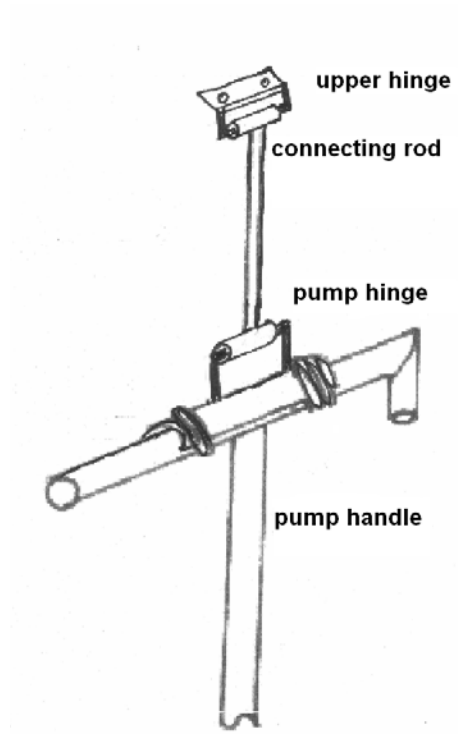
EMASsysm, first you drill two wells, 80 cm distant in between.



Then set up EMAS pumps therein. In case of using 2" jackets, flow pumps can be used, but if water is found to be at more than 10 meters depth, or if the recharge is not eminently good, it is advisable to use 1" standard pumps.

The remaining part of the mechanism is quite simple. The seesaw installed, arrange the connecting rod with its two hinges on both of its ends. Fastening between the connecting rod and the holder is made welding a 3/4" pipe which has been cut lengthwise and operates as a gearing, to which the holder is tied with a pneumatic tire strip (see the figure).





3 . <u>pumping of an excavated well</u>

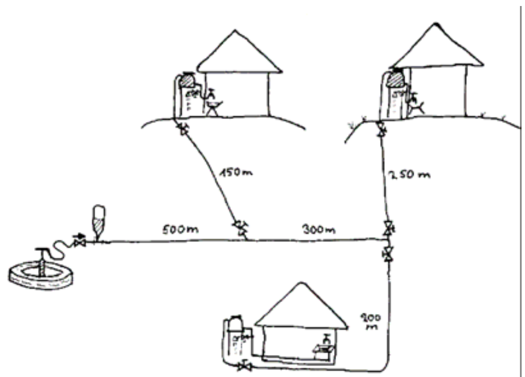
The system is quite similar to the pumping of a twin well. Laterally you set up two pumps, 80 cm distant in between. Given the inclination of the lateral pumps, the shaft of the "seesaw" must have the same angle. However, this means that the balance board will also have an inclination, making it most uneasy to step on it. Therefore, to level up the stepping spot, place two platforms which will operate as wedges on the board.

Remote manual pumping with the EMAS pump

The EMAS concept is not only referred to pumps and cheap drilling, but to provide complete solutions, from the water source until reaching the faucet at your dwelling. The standard type EMAS pump ejects water with a pressure up to 5 bar, which means that it elevates water up to 50 meters height. With this pressure, water can be conveyed horizontally until 2 Km, provided that the dimension of the tube be sufficient. Until 500 m, pumping can be carried out with a 1/2" pipe.

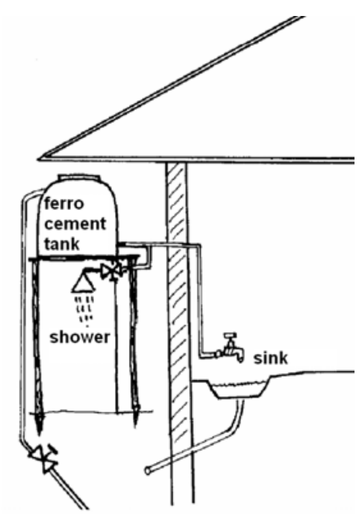
Air chamber

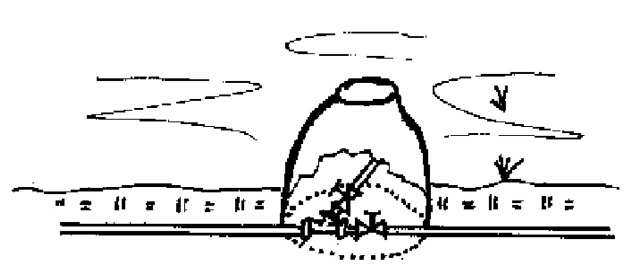
As its characteristic, the EMAS pump produces a pulsating stream. It is very difficult to convey a pulsating stream through a water pipe, because it originates ram strokes and friction is highly increased. Consequently, the pulsating stream must be transformed into a continuous stream. This can be done by means of an air chamber. The air chamber is described within the subject referred to hydraulic rams. As per the EMAS concept, the air chamber consists only of a PET bottle (plastic bottle).



Connections

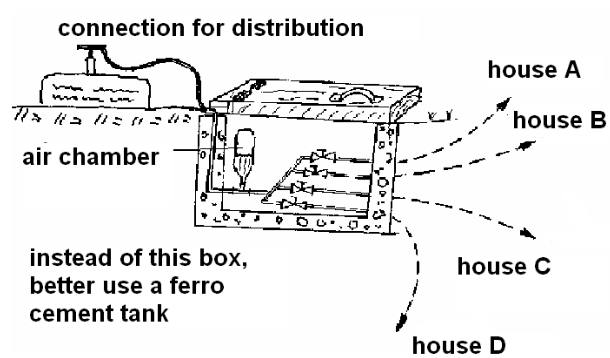
There are several forms to connect several dwellings to an EMAS pump. Perhaps the most advisable is the one that has the form of a "star", wherein each house lays out its water pipe from the well following a straight line. But this implies more piping and consequently higher costs. Its advantage is that you only have to go to the well, shut the other distribution faucets and then pump.



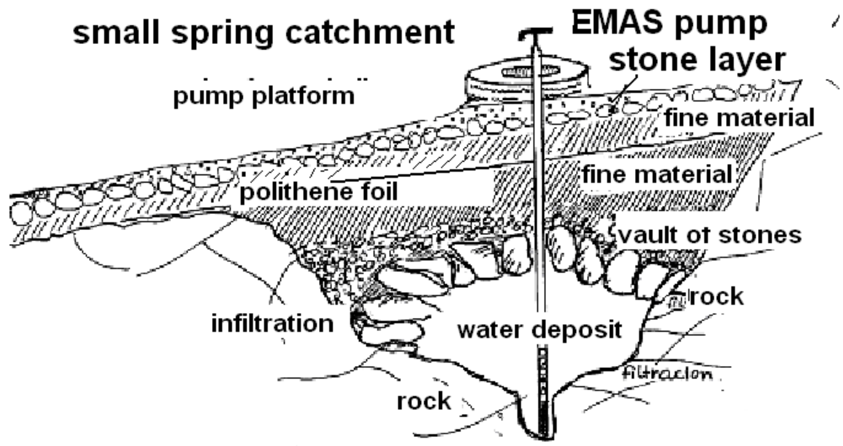


a small ferro cement tank without bottom protects the valves

You don't need to walk in order to shut the other connections. When you cannot choose the straight set up, you can choose to share the main faucet, as seen in this design. To fill the ferro cement reservoir at a given dwelling, first you must shut the stop-cocks of the other branches, and then pump. Even though there is no sight or sound contact with the person who pumps (due to the existing distance), it is very easy to communicate when the reservoir is full. Simply shut for a while the stop-cock located before reaching the tank; this will increase the pressure on the water pipe, the pump will harden and the person who pumps will realize that he may proceed.



Impounding from small springs



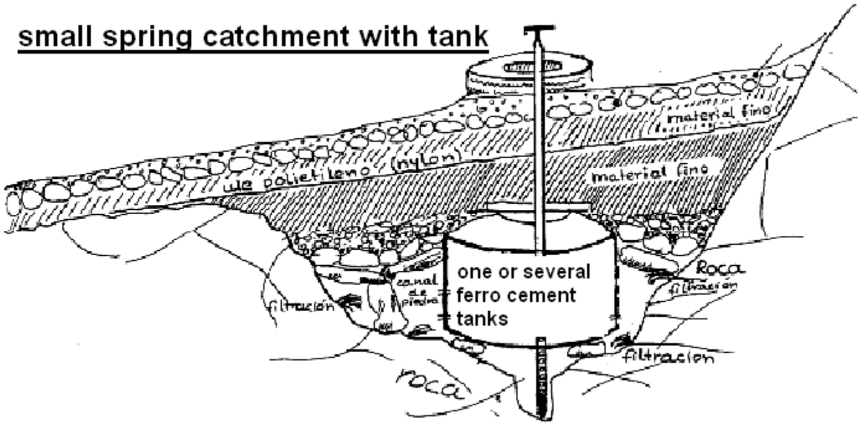
At many places, very weak water filtration exist which cannot be profitably used by means of a water pipe or a network system, but their water supplies many dwellings.
Generally they are unprotected, and at unattended hours even pigs bathe in the sole source of drinkable water. At those places, it is wiser to impound the spring adequately and set up a manual pump.

For small springs, EMAS has tested the following types of impounding :
A simple filtrating gallery built with stones, and a 200 liters ferro cement "pitcher" ('cantarito') as storage tank, very easy to build; its cost is of approximately the value of 2 cement bags. In case the deposit does not have the necessary capacity, filtrating galleries may be set up around it, or several 'pitchers' may be used. If more than 1000 liters storage are needed, it is better to dig carefully around the spring until you have obtained a deposit that is large enough. If the soil is not quite firm, the walls are plastered with cement, and to cover them, an arch is set up, made of stones. However, before you start a design, consider the following aspects :

1 . in the past, which fluctuations have occurred in the spring volume; has it ever been dry?
2 . how much water does the spring produce per day / hour / minute / second ?
3 . how many inhabitants receive their supply therefrom, and which is the present demand?
4 . which is the consumption during peak hours?
5 . which other water sources still exist?
6 . would water supply be increased with an additional impounding?

These estimates are also applicable for excavated wells, since it is not important if the filtration is located at one, two or 10 meters depth. Please see reservoir well, page 80.

How to obtain an impounding from a spring
First you must clean the filtration from any loose material (sticks, mud, stones, garbage, etc.). Then measure the filtration volume, counting for a while how many buckets have been filled. From that data you will obtain the volume in liters per second, per minute or per hour, if the filtration is weak. Besides, you must calculate which type of impounding is convenient. For example, you may decide to use a ferro cement tank with 200 liters volume and a filtrating gallery around it, which can also store about 100 liters.



Subsequently you have to give a shape to the well, so that there is enough room for the tank, plus the filtrating gallery around it. Then introduce the ferro cement tank. The tank has lateral bores through which water flows in, most of all at its lower part. Around the tank, build a filter with stones arranged tunnel-like; this space is then filled with water and it serves as an additional reservoir. Then attach the guide pipe to the tank. It is one measure larger than the pump cylinder.

On top of the filter spread a rip rap layer, then some thick sand and on it, argillaceous earth - about 30 - 60 cm - which compacts. Then the surface must be flattened and a polyethylene film (nylon, oilcloth) arranged on it.

The compact earth and the film are made waterproof on the surface. Before stone paving the area, another layer of fine material must be spread on the film, to protect it from damage. About 20 cm will be enough. This material must be compacted in a similar manner, and then you should set up the stone paving.

When pumping, water is always spilled; therefore prevent mud from being formed.

Of course the ground must have a good slope, so as to avoid stagnant waters. To prevent stones turning loose, spread on them a cement layer, mainly around the pump, so no infiltration fissures may appear. For an additional platform for the pump, an old tire will do. Finally introduce the FLEXI pump to the guide pipe.

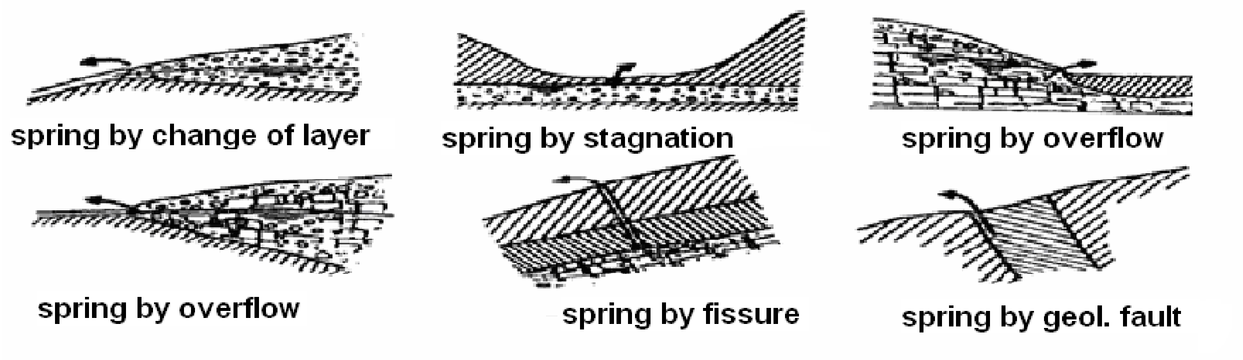
Impounding through the arch or vault is quite similar to the preceding one. Instead of the ferro cement tank, build a cavern with stones or with bricks. Usually, an arched board is used, on which stones are arranged. With this mold, you move forward line by line along the board. The last segment must be arranged without the board; otherwise it would remain inside. When the stones of each segment have been arranged, a cement mortar is spread in the space between stones or bricks, to fix the arch or vault.

The arch proves to be of advantage for impounding on rock, or if the earth is firm enough, since in these cases it is not necessary to build walls.

Remark : If stones are not available, you can use well baked bricks.

Filtration gallery for watershed impound

A watershed is the place wherefrom underground water naturally flows.
Kinds of watersheds :



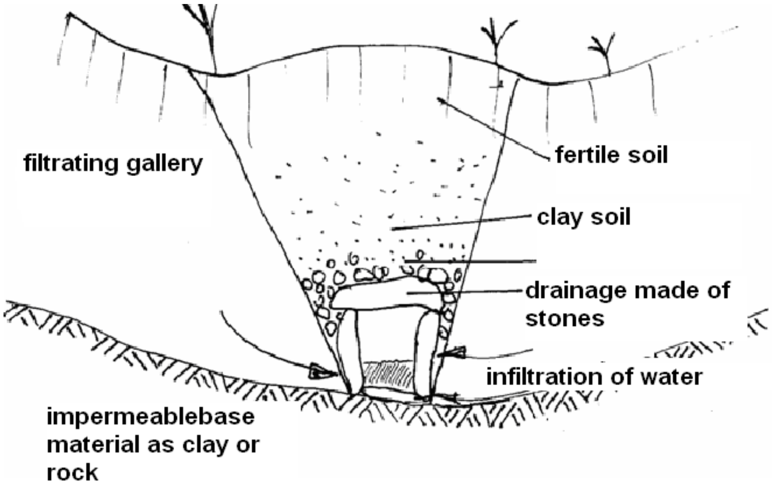
Watersheds have different properties;
some of them have different volume, according to the season; others maintain a permanent volume; other watersheds decrease during the rainy season, and increase in the dry season; some of them have a scattered source, and others have only one stream; there are thermal, mineral watersheds, etc.

Before impounding, first you have to analyze which is the cause of the watershed and under which type it will be subordinated. On principle you should dig carefully, so as not to pierce the clayey strip. Water can be lost again in the porous material underneath. This is applicable most of all when water originates at a foothill.

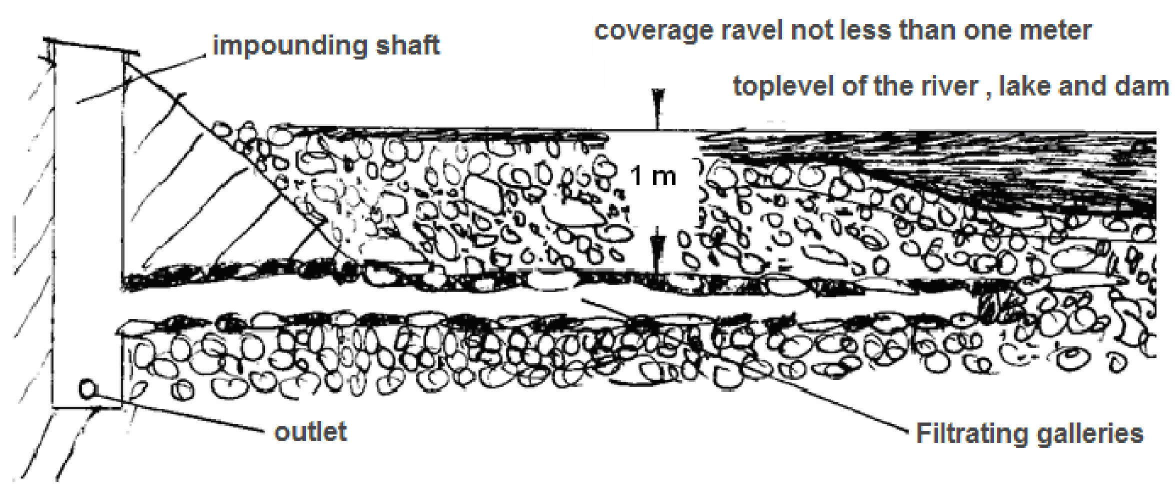
Generally too much scraping does not increase the volume of the watershed, and if it does, it will be for a short while.
Impounding from a watershed must be protected against all possibility of pollution.
Frequently, due to lack of knowledge, the impound is not taken from the watershed, but from the newborn brook. But along its way to the intake, many possibilities of pollution already exist. The classic and correct form of an impounding from a watershed is the filtrating gallery. A filtrating gallery is an underground tunnel wherein water is accumulated.

Filtrating galleries can be set up with different building materials, starting with cement piping (but be careful! In aggressive waters this material soon dissolves, and the gallery is spoiled), plastic piping with grooves (be careful! If the grooves are too thin, roots may cover them, and when the pipe has a narrow diameter, roots may cover it); water resistant boards or pieces of wood, double baked bricks or, what is best and cheapest : local stones.

Stones offer good resistance and allow to draw a larger underground channel.
(To impound a volume of 1 liter / second, a 30 x 30 cm channel will suffice). The channel is covered with flat stones.



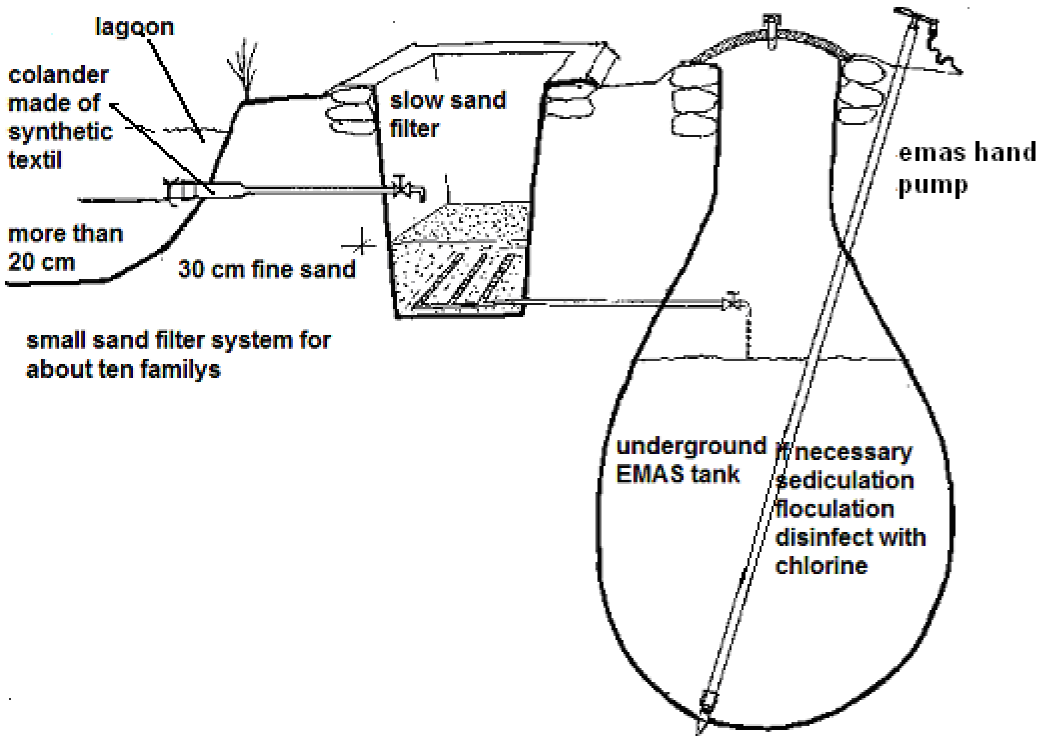
On top of the channel, arrange gravel and rip rap. Cover the rip rap with at least 60 cm of vegetable mold. It is advisable to mark the underground location of the channel with big stones or other signposts, and prevent weeds from growing on it. The filtrating and underground gallery also prevents penetration and washout of filthy waters. Filtrating galleries which impound water from underneath a river bed are quite common. When the river flows in a squall, the underground impound receives no damage.



In industrialized countries, this method is also used for impounding coastal filtration from rivers and lakes, in order to obtain water with a better quality.

Intake of surface waters from a lagoon, breakwater, river

When no underground waters exist which are adequate for consumption, or if waters are too deep, and their extraction would be too expensive, or if the pluvial water roof is not sufficient, the possibility exists of an impounding from surface waters. When there is no river or brook, only stagnant waters remain.



You can have a water intake from a natural lagoon or from an artificial lagoon, whether permanent or temporary. Artificial lagoons are also called breakwaters, cofferdams, ditches, etc. Generally they are excavated with heavy machinery at a low site. Pluvial water from ditches or ravines accumulate therein, and they represent a volume stored for dry months. In many places these breakwaters are the only water source for the population and for cattle. Animals drink therefrom, people wash their clothing and they also drink their water. Strong winds carry all kinds of dust. Therefore these waters are usually polluted, even though many diversities of aquatic plants and microorganisms which live therein, continually degrade filth.

It is important to protect the breakwater from chemical pollutants such as pesticides, oils and other poisonous substances.

Here you can observe the impounding from a cut water for several dwellings. It is important for the intake to be located at the deepest spot, but at least about 20 cm above the surface, since usually an anaerobic mud is formed at the bottom, and it gives water a bad flavor. Deeper it is, water will be fresher, and also the volume stored will be greater whenever the lagoon has a tendency to be dry.

The intake pipe has a larger diameter than the remaining intake pipe. The pre filter has grooves and it is covered with a synthetic cloth lining. For this cloth you can use a bag sewn from a synthetic blanket, fastened to the pre filter pipe.

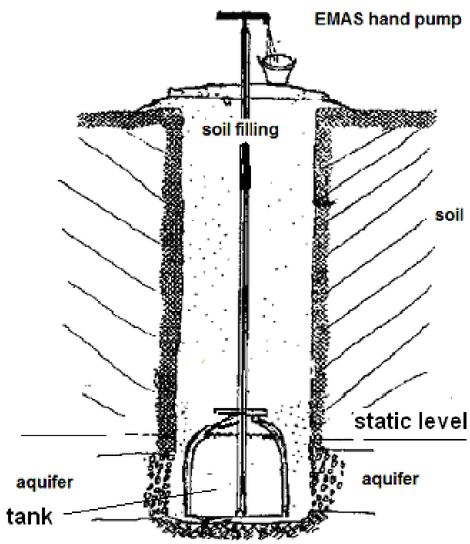
The slow filter is located a few meters distant from the breakwater. It can be a round or square excavation, built in a similar way as a cistern. It has a stop cock at the intake. This stop cock is to be shut only when the filter is obstructed. In such case, the sand is drained; dirt forms crusts on its surface, which are removed when it is dry. You can remove them with a ruler. Inevitably, when cleaning the slow filter some sand will also be removed. So once in a while, you have to refill it with new sand.

At the bottom of the filter there is a screen which has grooved plastic pipes; it is covered with a polyester cloth, the same cloth used in wells drilled with the EMAS system. Water passes slowly through the fine sand. There, microbes are kept back. Then water flows through the cloth to the grooved pipe, and continues towards the cistern. Before it flows into the cistern, it has to pass by another stop cock. The purpose of this stop cock is to regulate the flow speed in the slow filter, and therefore to determine the quality of the filtered water. Then water falls into the cistern. Usually drinkable water is pumped from the cistern by means of the remote drum, until reaching the ferro cement tanks at the dwellings.

Sometimes you will find that water continues to be turbid, although it has passed by the slow filter. In such case flocculation may be provoked, pouring some aluminum sulfate from the control pipe to the cistern. (Many natural saltpeter contain aluminum sulfate). The exact amount should be determined through tests. Usually 1 - 2 spoonfuls of aluminum sulfate are enough for a 5000 liter cistern. After the flocculation, all that is turbid is deposited at the bottom of the cistern. Inserting the EMAS pump through the control pipe of the cistern, the sediments may be suctioned like when cleaning a swimming pool.

Once crystalline water has been obtained, you can disinfect it with chlorine. The dosage of chlorine will be determined according to the size of the cistern.

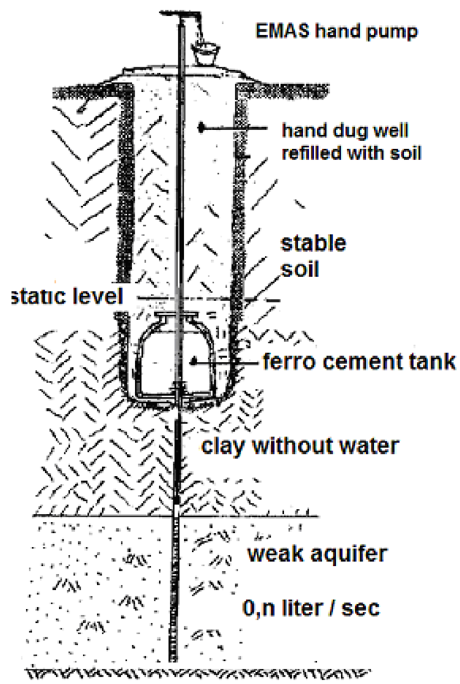
When surface waters are much too muddy, for instance from a river or from a new breakwater which still has no aquatic plants, it is advisable to provoke flocculation and sedimentation before reaching the slow filter. Sometimes muddy waters from a river flocculate by themselves when they are stagnant, and many times they do not need aluminum sulfate. In this case you can dig a pool next to the river, and from this pool convey water to the slow filter. If no flocculation occurs in a new breakwater, it is wiser to build a cistern or a flocculation tank before reaching the filter where the dose of aluminum sulfate is determined.



Single well with underground reservoir or refilled well EMAS drilled well with compensation reservoir

Refilled wells are commonly used in Asia and in other parts of the world. Their advantage is that building them is most inexpensive, since they do not require a coating. Besides, they are better protected against pollution.

The disadvantage is that they can rarely be filled with sand, and when the phreatic level drops during years of drought, no possibility exists to deepen them.



EMAS pattern "rooted" reservoir well

The EMAS pattern "rooted" reservoir well is the ideal solution in areas with weak aquifers. Its cost is much lower than the one of an excavated well, with full coating It is made waterproof and is protected from pollution; therefore it is more hygienic; sand cannot penetrate through its fine filter; during low water periods it always keeps its feeding 'root'. This well has a higher yield, and its excavation is less dangerous.

Besides, before excavating you already know the depth it will have; the volume and the quality of the water to be produced by the well.

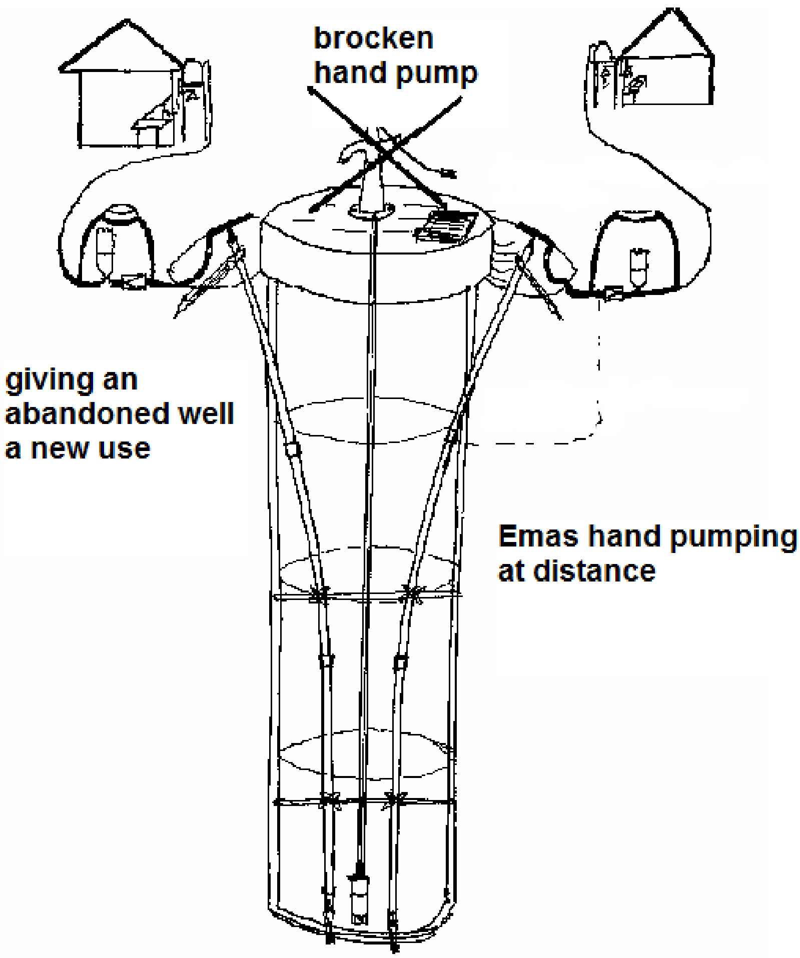
You begin with the usual exploration drilling of the EMAS system.

When testing, if you observe that the aquifer of the well is not sufficient for direct pumping, you should set up a ferro cement tank, to compensate it.

For this purpose, excavate around the EMAS well down to a few meters below the phreatic level. From drilling you will already know its geological profile, which in this case is clayey, and therefore water will be scarce, and you will find difficulties when digging. When the excavation is finished, the pre manufactured ferro cement tank is brought down, above the well pipe, and some holes are made to the pipe at the bottom of the tank. When pumping, water will flow through these holes from the tank to the well, partially feeding the pump. At times when no pumping takes place, water at the well rises, filling the tank once more. Thus the tank compensates the higher demand of water when pumping. The size of the tank depends on the volume of the well drilled, and on the continuous demand. The usual size is 150 liters (regarding how to set up the ferro cement tank, please see the module referred to "ferro cement tank").

<u>Traditional well with defective metallic pump replaced by an EMAS pump, and remote manual pumping</u>

Many times it is not necessary to look for new sources of water and spend large amounts of money; you can simply improve the existing source. In this case you observe a well adequately set up with a spoiled metallic pump. The useful function of the pump was limited only to provide a better quality of water. When the pump was spoiled, the users uncovered the well and, like they had done before, they used buckets to get some water.



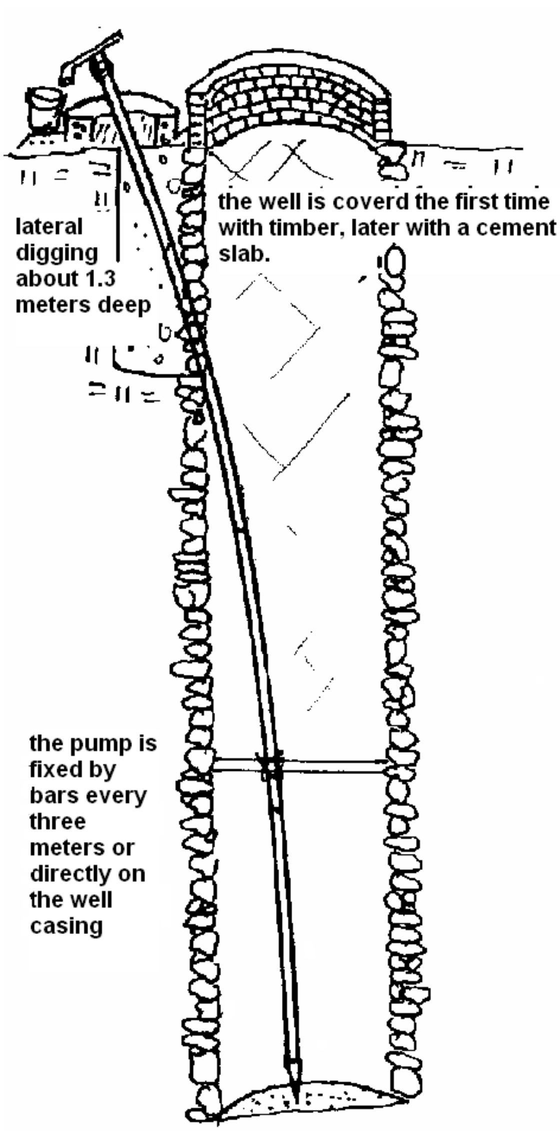
The expenses of repairing and maintaining the pump were not in relation with its being useful, and therefore the subject was unimportant.

The figure shown herein is quite different; by means of manual pumping, water is received at the domicile, at the kitchen dishpan. Now water <u>does</u> provide comfort and it makes life easier. Therefore the neighbor does not wish to give up this service. Maintaining an individual or shared micro system does make sense; the user is willing to spend his money and time to maintain it.

An essential piece herein is the EMAS pump, which the user himself learns how to set up and then knows how to repair it. The pump has a low cost, and all necessary materials can be obtained at the local hardware store.

Remark : as protection for the air chamber and for the check valve, a bottomless 'pitcher' will do. It has been evidenced that inside the 'pitcher' the pieces have a better protection than when they are in a small case. Besides, vehicles do not run over it, because the 'pitcher' looks like a big stone.

Setting up an EMAS pump in a well which has no antecedent of a former pump



Thousands of pretty wells exist, hand excavated and covered with stones or bricks. Such a well has cost a lot of money and efforts, therefore its owner takes care of it devotedly. Given its characteristic, water can only be obtained with buckets. The well remains open. The buckets and the wind carry dust, as well as other dirt, and this turns water into a scarcely hygienic liquid.

If now, in our eagerness to enhance the quality of water, we propose the owner to shut the well with concrete and set up therein an EMAS FLEXI pump, we are surprised when the owner refuses this convenient offer.

As many other citizens, he does not believe that pumps are endurable, and he is afraid that, in case the pump is spoiled, the well will remain shut and it will be impossible for him to get some water, not even with buckets. Therefore, he does not authorize this work.

The case is quite different if we propose to set up our flexible pump laterally as regards his well. This only implies to make a small hole in the jacket of his well, and leaves the well hole open for any case that may occur in the future.

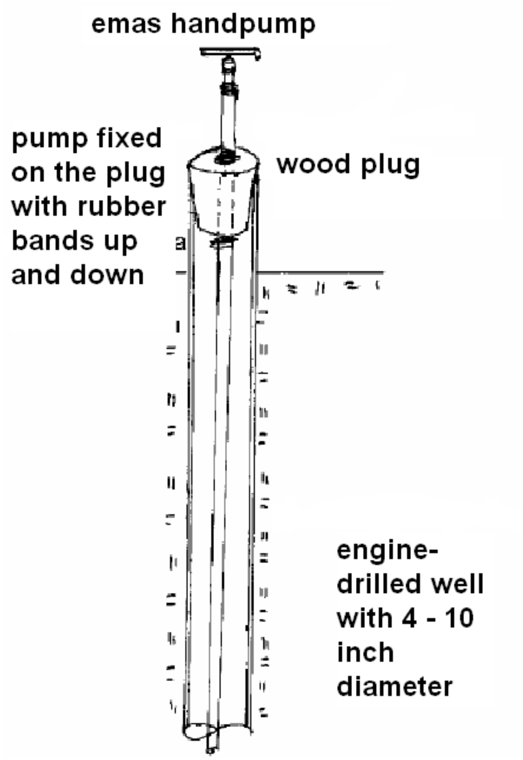
These are the steps :
Dig a hole of approximately 1.50 meters next to the well, following the jacket. With a chisel, open a hole at the wall of the well, through which a PVC pipe (1 1/2" - 2" sanitary) will be set up; it will serve as a casing for the pump. At its extreme, the casing has a sharp end that will be nailed at the bottom of the well and thus make it steadier. About 30 cm above the well level, the casing is drilled for water intake to the pump. If the well is too deep, the casing must be fastened every 3 - 4 meters. Then the excavated hole is refilled. It is most important for the material to be sufficiently compact, mixing earth and water. For a platform, an old tire will do. Finally, arrange the pump in the casing.

So the wind carries no dirt which may fall through the well hole, we propose the owner to cover it provisionally with wooden boards and plastic.

This technical proposal only allows to set up one EMAS pump, because it is built with flexible materials which do not affect a slight bending or curve.

Setting up an EMAS pump in a wide well drilled, or in an excavated large well

1 . Well drilled

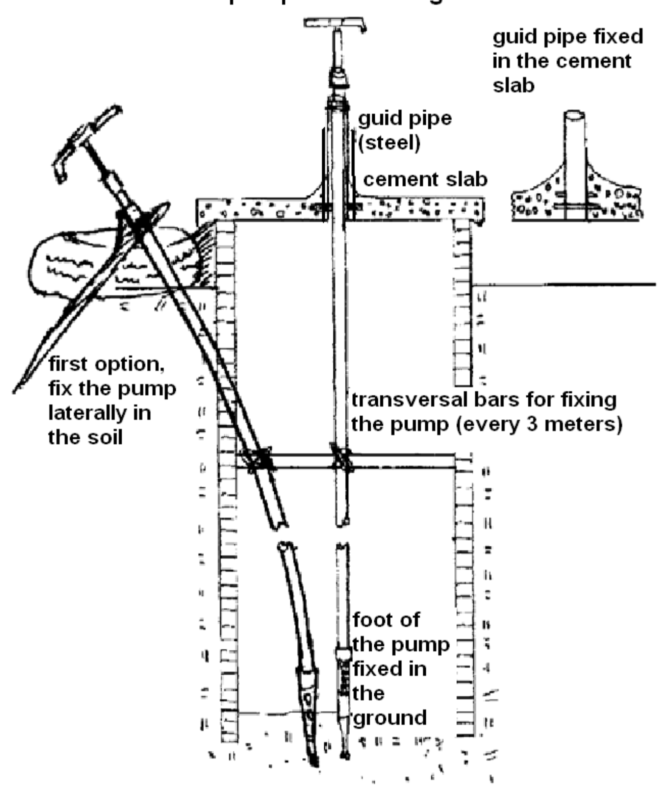


When a drilled well already exists, wherein the metallic pump is spoiled, we offer the FLEXI pump to replace it. Since the FLEXI pump has no bolts to be fastened on its former base, this must be adapted at the well hole.

The easiest and quickest thing to do is a sort of a conical plug made of fine wood, drill a hole at its middle part, as per the diameter of the cylinder, wedge the plug on the well hole and arrange the pump through the hole of the pressure plug, tightly filling it with tire strips. It is advisable to use dry wood, so it will swell due to dampness; this will make it tighter in the well and the pipe of the casing. Thus you prevent polluted waters from getting into the well. Without a cat head, it is quite complicated to perforate the plug. Artisan-wise, you can carve two halves of a plug, and joining them you will form a sort of a plug.

Instead of using a wooden plug, you can also use one made of concrete. In this case it is advisable to cast a guide pipe for the pump at the middle part of the plug, and let it stand out about 15 cm (a 1 1/4" pump needs a 2" guide, and a 1" pump needs a 1 1/4" guide). The conical shape of the plug is compressed inside the well pipe and thus the hydraulic seal is obtained. When plastic sheets are arranged around the plug, the sealing is even better.

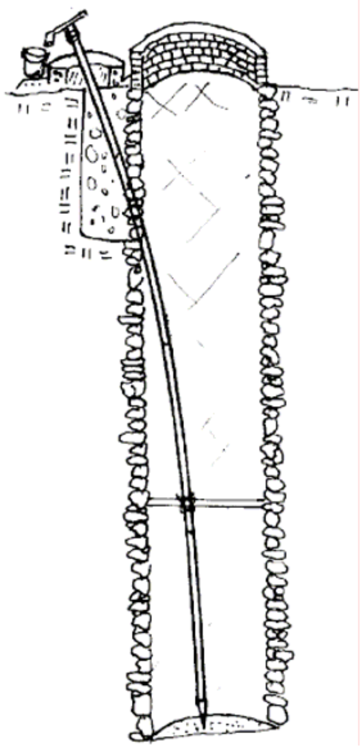
EMAS handpump in hand dug well



2 . Excavated well

When a FLEXI pump is adapted to an excavated well, a round shaped concrete tile is cast, and at its middle part (or at one of its sides) you arrange the guide pipe. The guide pipe can be of thick PVC or galvanized iron, and it must tightly hold to the cement. For this purpose, small bars or beams can be arranged, or grooves may be cut in the pipe. The pump is introduced into the guide pipe and, as usual, it is fastened with tire strips.

When the well has more than 4 meters depth, the pump, or even better, the pump case, must be fastened on stands that go across the well every 2 - 3 meters. If the sharp end of the pump moves in the well, the water will be turbid. In order to prevent this, the sharp end must be pressed down and lie inside the bottom of well. The sifter has to be about 10 cm above the ground level.



3 . Lateral pump

Thousands of pretty wells exist, hand excavated and covered with stones or bricks. Such a well has cost a lot of money and efforts, therefore its owner takes care of it devotedly. Given its characteristic, water can only be obtained with buckets. The well remains open. The buckets and the wind carry dust, as well as other dirt, and this turns water into a scarcely hygienic liquid.

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So the wind does not carry any more dirt which may fall through the well hole, we propose the owner to cover it provisionally with wooden boards and plastic.

This technical proposal only allows setting up one EMAS pump, because it is built with flexible materials which do not affect a slight bending or curve.

The hydraulic ram

Hydraulic ram stroke, its meaning

Drillers and technicians who perform highly important hydric works are well acquainted with the hydraulic ram.

Most frequently, hydraulic strokes are the cause of bursting in a water pipe, because they can make the pressure rise up to 20 times more than what is normal.

Water running in a piping can be compared to a railroad in motion. If the train suddenly hits an obstacle, although at reduced speed, the collision is violent and it causes damage because it cannot stop suddenly. The same thing happens with water when it is running in a pipe and is suddenly stopped.

We all know the phenomenon that occurs when water with air is received from the faucet. We say that the faucet is 'coughing'. Now this is what happens :

Air can be compressed (tires, compressor, etc.) but water cannot be compressed. Therefore, air has different fluid properties than water. An air volume can be evacuated by a determined exhaust orifice much faster than water, both being under the same pressure. When air gets into a water pipe, air bags are formed and they compress according to the pressure. When it runs out from a faucet or a final tap whereby pressure is discharged, air leaves the orifice at a speed much higher than water; a depression is formed in the piping, behind the air, and this "vacuum" causes all the water inside the piping to accelerate. When, at a higher speed, it reaches the outlet orifice, not all of it can pass through. Since water cannot be compressed, pressure increases for a few seconds, until the whole water column is held back inside the piping and it reaches its normal pressure.

The same thing happens when a stop cock is suddenly shut. Pressure is increased, because water running inside the piping cannot stop so suddenly.

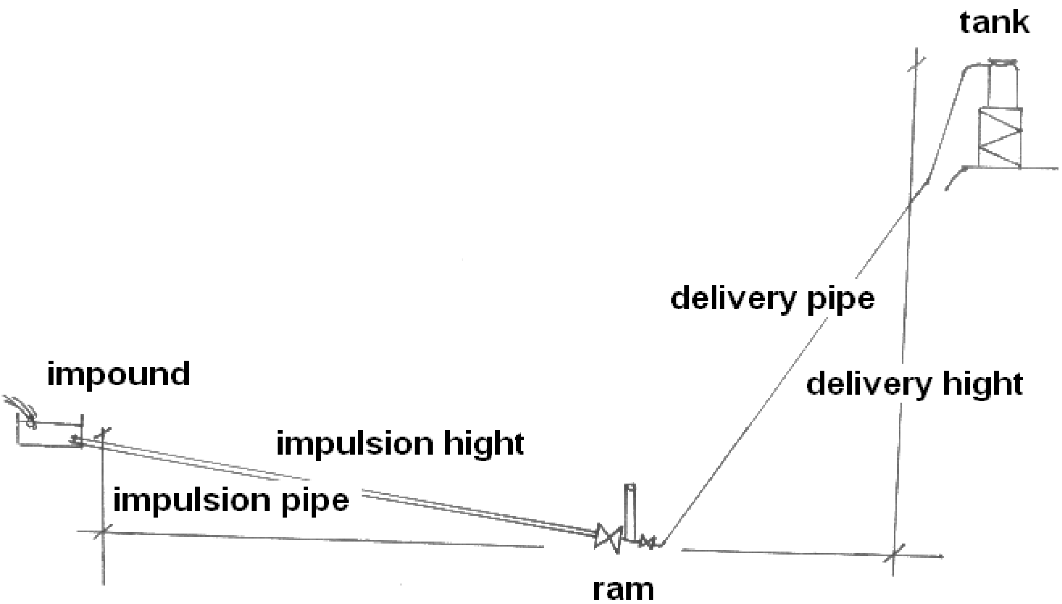
Longer the piping is, and higher its flow speed, the stop cock must be shut more slowly. The air in the water piping can also provoke a hydraulic ram stroke.

The hydraulic ram

In the hydraulic ram, advantage is taken from the pressure stroke that originates when a water column in motion is suddenly stopped. This column is referred to all the water in motion, running inside the piping (it is not referred to the vertical aspect as an expression of pressure).

The hydraulic ram is a sort of a pump driven by the energy of water in motion itself. A ram is easy to build, it is endurable, it does not consume fuel, but it pumps only a small part of the water it uses (3 - 10%).

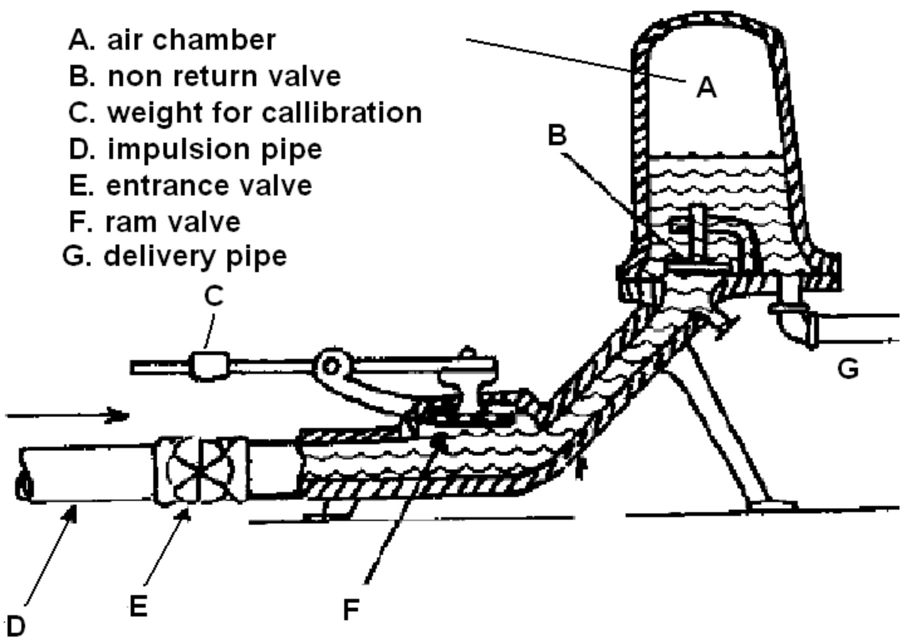
The hydraulic ram takes advantage of the principle that a water column in motion must not be stopped suddenly.



The use of the hydraulic ram is limited, but whenever used, it is greatly profitable.

Where can a hydraulic ram be used?

To pump water upwards from an irrigation channel;
To pump water upwards from a watershed with good flow
To pump water upwards from a river.



How does the ram operate?

For a ram to operate you need an impulse piping, a valve that can be regulated, quickly being shut when a certain flow exists, and opened when the flow stops. You also need a check valve and an air chamber.

When a cycle starts, water is in motion inside this piping D. When no flow exists, weight surpasses © and the operation valve opens. Now water starts running in the impulse piping and it goes out through the operation valve. Since the outlet is free, water continues to accelerate to such a point that the stream raises the disk of the operation valve and shuts it instantly. The water column that was running inside the impulse piping cannot stop as suddenly, and for a while it provokes a pressure that is much higher than the one of its own slope. This pressure opens the check valve (B) in the ram, and allows a good stream to get into the pressure chamber (A). The water column stops, the check valve is shut, the operation valve opens, and a new cycle begins.

Parts of a hydraulic ram

Slope : For a hydraulic ram to operate, 1 meter slope will do, although more than that is even better. When the slope is more pronounced, water has a higher acceleration in the piping, it runs faster and intervals are more frequent. Therefore, more volume exists.

Impulse piping : The intensity of the stroke, as well as the pumping pressure, depend on it. Longer it is, more water volume accelerates, and when shutting the operation valve, the stroke is harder.

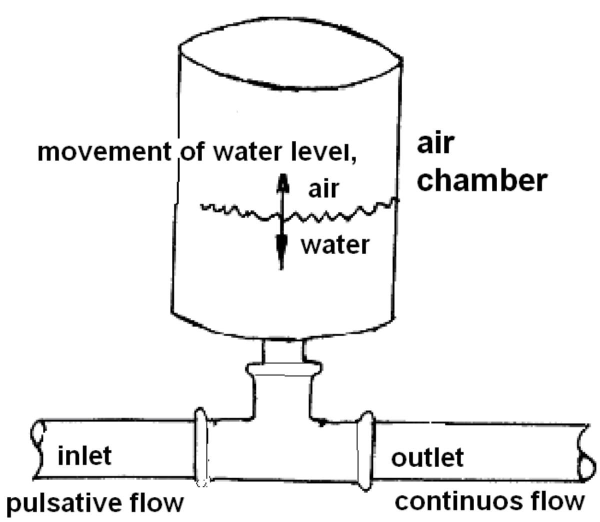
If the piping is long and has a slight slope, you must wait several seconds until the water column has reached the sufficient impulse so as to shut the operation valve. Therefore : longer the impulse piping is, harder the stroke will be; pumping will be higher, but intervals will be longer, and you will obtain less efficiency with more spillage waste. Also, expenses will be higher, because of investing in the piping.

For a hydraulic ram to operate, 1 meter slope will do, although more than that is even better. When the slope is more pronounced, water has a higher acceleration in the piping, it runs faster and intervals are more frequent. Therefore, more volume is pumped.

Operation valve

This valve can have many shapes, and it is not difficult to set up. It is very important for its dimensions to be according to the diameter of the piping, and to eject without friction all the water volume while it accelerates. Also, it must shut firmly.

The valve should open automatically once the pressure has gone down to the hydrostatic value. Therefore it must be adjustable. Generally weights or springs are used to lower the disk, and thus oppose the hydrostatic pressure (resulting from the slope).



Check valve

You can use a check valve available at the local market, or build it yourself like the FLEXI pump foot valve. However, it is wiser to purchase it, because it plugs firmly.

Air chamber or pressure chamber

Its function is to transform into a continuous stream the pulsating stream that goes out from the hydraulic ram. Thus the friction inside the piping will decrease, and the pumping yield increases. When the stream suddenly gets into the air chamber, all that water cannot instantly be ejected.

Air in the chamber can be compressed like a spring, and it ejects water when no more water intake exists from the hydraulic ram. Air chambers are not used only for hydraulic rams, but also for piston pumps, as well as for all kinds of EMAS FLEXI pumps, most of all when you wish to pump water to a greater distance. All air chambers need adequate maintenance. Water under pressure has the property of absorbing more air than when it is in its usual condition. Therefore after some time, air inside the chamber decreases, and it is not useful any more. According to the characteristics of the system, air in the chamber must be increased at given times. For this purpose, every chamber has a pneumatic valve.

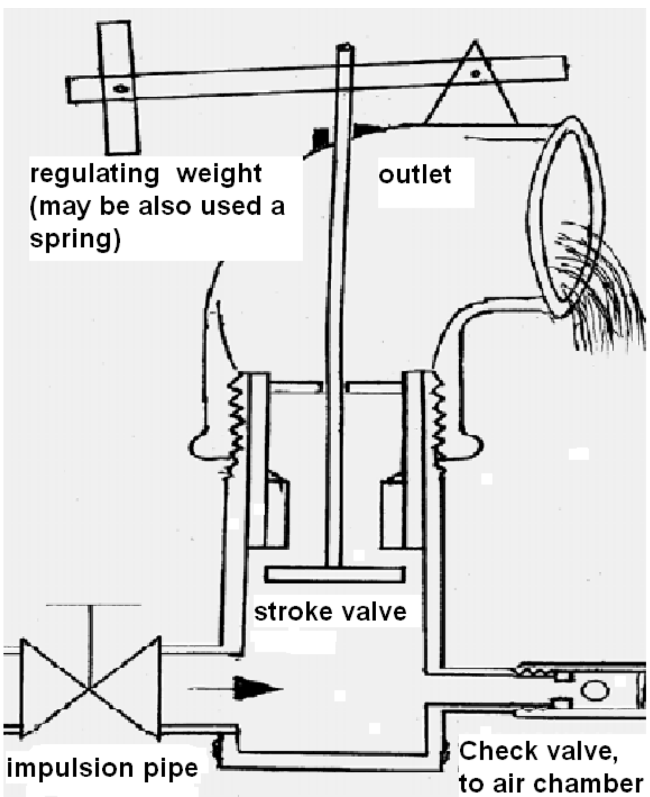
<u>How to set up a hydraulic ram</u>

The design shows how you can set up a hydraulic ram using ordinary materials.

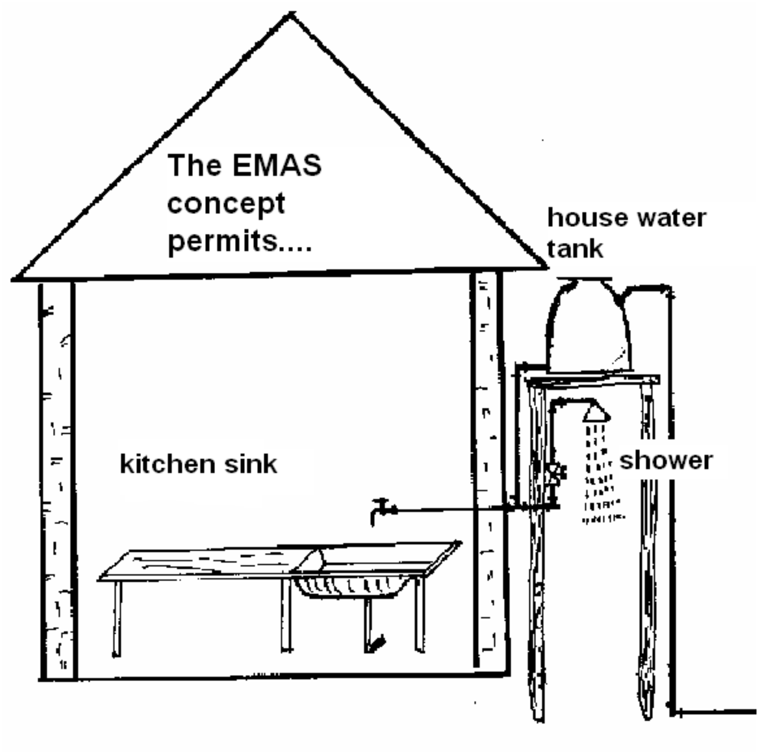
The pattern is 1 1/2". On a nipple of a 2" and 20 cm length piping, weld a 1 1/2" short nipple, to be connected to the impulse piping. At the opposite side, a 1/2" nipple is welded, to which the check valve is screwed up. You can make a stroke disk from a 5 mm plate or from a piece of spring. Otherwise, for this purpose, an old engine valve will do.

In a right angle, the connecting rod is welded on the disk. The valve seat can be obtained from a 2" pipe reduced to its inner diameter, and another one, of 1 1/2". For the guide of the connecting rod, a small beam perforated in its middle part is weld. A 1 1/2" bend forms the outlet. On its upper part, it has a perforation whereby the connecting rod passes. Its operation can be regulated by means of a lever with weights. To fix the stroke disk on its seat, connect the upper part of the connecting rod to a drill, and turn it. At the same time, sand is distributed between the disk and the seat.

Once the disk has been fixed to its seat, plug firmly when shutting. It is important that between the disk and the wall of the 2" pipe, a space be left, equivalent to an area of 1 1/2".



Household installation



When people have to fetch water from a certain distance, water becomes "a necessary evil".

When water is received from the faucet at the kitchen or to take a shower, it becomes a symbol of having a certain status, because it provides an immense comfort, it saves time and increases personal as well as nourishing hygiene.

Only then, water has the necessary value for the user to be willing to assume its maintenance and repair expenses.

Therefore, this kind of supply is truly sustainable.

Its cost is not so high, since the user assumes most part of the expenses made for an individual installation.

Household installation is an integral part of the EMAS concept, and it has been made possible due to the characteristic of the EMAS pump that ejects water with the necessary pressure from its source up to an elevated distribution tank.

Of course a water installation can be performed with many de luxe specifications (such as a jacuzzi for the upper class), but the basic demand at the rural and sub urban environments is to have water in the kitchen, and if possible a shower (for places with hot weather).

The ferro cement tank (pitcher; "cantarito" in Spanish) is arranged on 4 solid wooden supporting beams at about 2 meters height. The distance between them should not exceed 80 cm, so a plastic sheet set around them can be used as a screen when taking a shower.

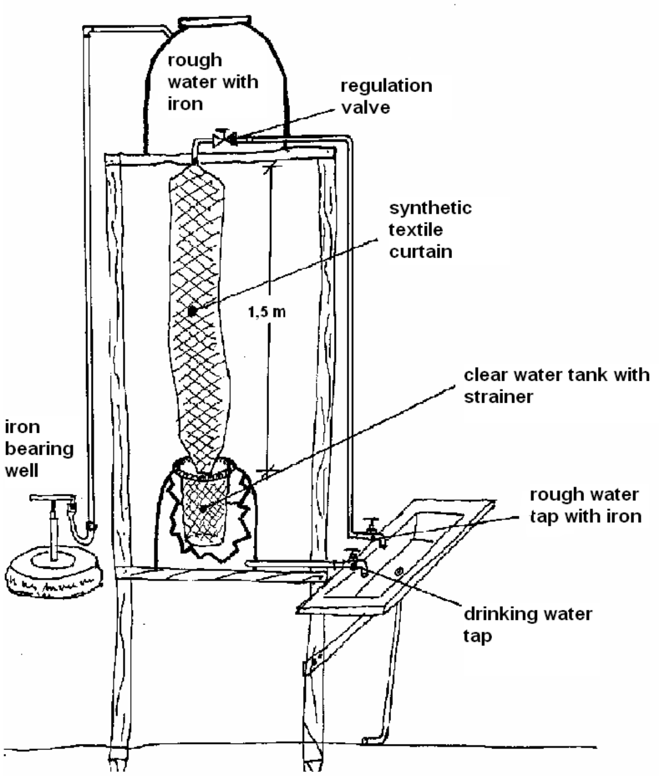
The laundry is set up 80 cm high, and the faucet 1 meter high. The drain pipe can have from 3/4" to 1 1/2". It has been observed that a 3/4" polyethylene hose is sufficient, and also very inexpensive. For the household installation it is advisable to use PVC 1/2" pipes, with folding or coiled accessories. Accessories built by yourselves will also be useful, since there is not much pressure in this system.

How to eliminate iron

a : physicochemical treatment

Iron is eliminated oxygenating (airing) water. In treatment plants, waterfalls, compressed air or other mechanisms are used to set water in contact with contact air.
Water is left to be settled during half an hour, so that flocculus may be formed.

These flocculus settle at the bottom, which is funnel shaped, and finally water passes through a sand filter. There the remaining iron small clouds (flocculus) settle.



This is how to obtain colorless water, with no iron flavor.
If waters are too soft (with no mineral content) and with a low Ph, flocculation does not operate satisfactorily. To assist flocculation, the Ph is increased, pouring liquefied lime. In ferrous waters at Chapare, lime cannot be used, because it is a controlled substance.

b : biological treatment

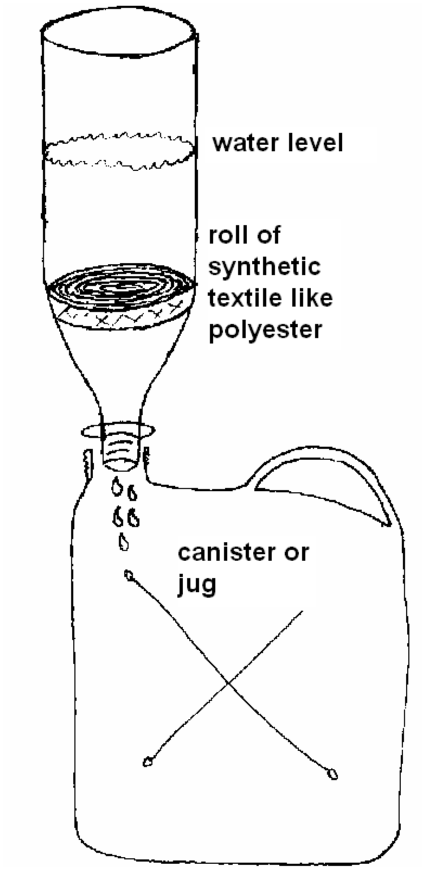
Remember the reddish spots of rust that you can observe by the riverside. Usually we find it repulsive to touch such a "filth", but if we closely observe them, we shall see that those phlegms look like loose algae.

In fact they are colonies of iron bacteria which take advantage of the energetic potential existing between iron as solution, and iron as rust.

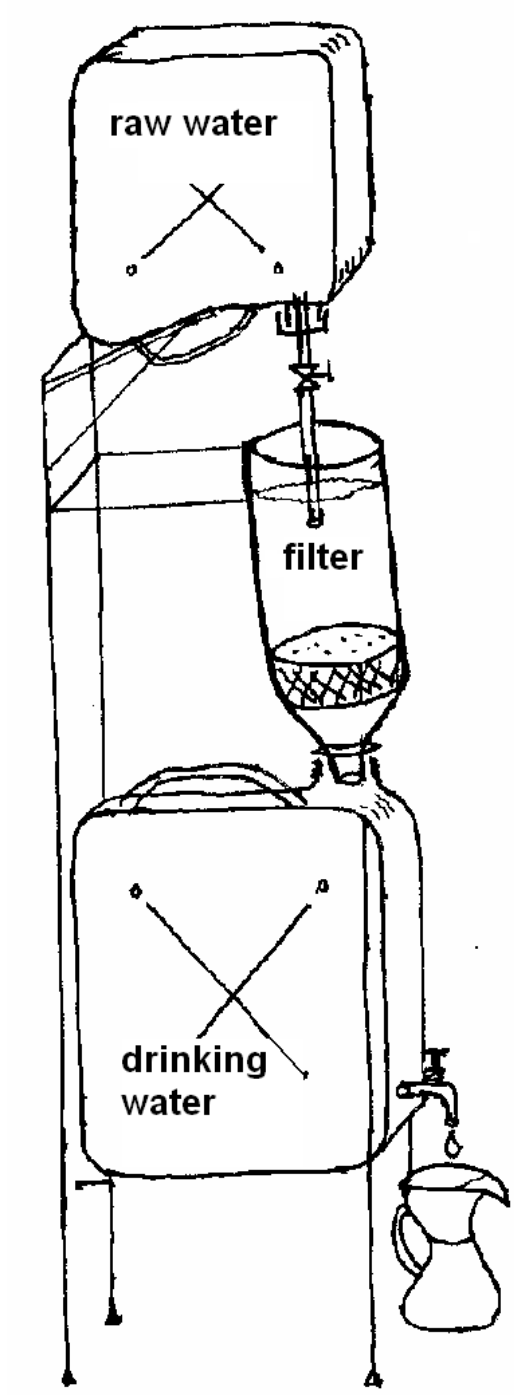
We also observe that, after running over a certain distance, the color has disappeared and this water looks like any other water. What we are observing is a biological treatment for the elimination of iron. If we do something similar in our household use, we will also obtain water with no iron content. Here you can see a pattern that has been tested, with excellent results. It is quite inexpensive to set up, and its maintenance cost is almost nil, since the curtain belt must be cleaned only once or twice a year. For the curtain you can use a polyester cloth, or simply a strip from a quilt. The tanks located on top and at the bottom, are 'pitchers'. More iron the water contains, slower the dripping will be. With a strip 1,4 meters length and 20 cm width, you can treat approximately 150 liters per day. Instead of a filter you can use a synthetic cloth as strainer (or another strip from a quilt), to be arranged on top of the receiving 'pitcher'.

The household installation usually has two faucets : hard water runs from one of them, for usage like dishwashing, etc., and the other one with water which has no iron content, used for cooking, drinking and washing clothing, since water with iron content leaves stains.

Bottle filter and EMAS filtration plant



Surface water from the 'curichi' (pond), cofferdam, lagoon or river is not drinkable. To make it truly drinkable, microbes must be eliminated with chlorine or another disinfectant (i.e. lavandina).



Chlorine is not very effective in turbid waters, and moreover it has an unpleasant flavor.
Consequently, first water must be made clearer, using a filter.

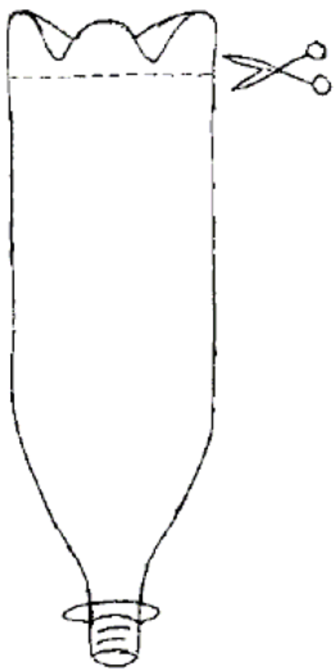
The "Popular Filter" described herein, is easy to build with an old plastic bottle; its cost is almost nil, it is very effective, its weight does not exceed 1/2 kilo, and due to the transparency of the material, it allows an excellent maintenance.

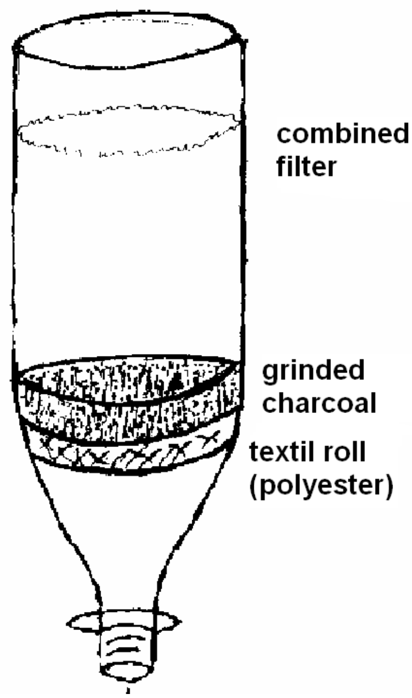
You need a plastic bottle, like those used to be discarded or returned, approximately 100 grams of polyester fiber, or a piece of polyester cloth, wherefrom you will cut strips, or in case no cloth or fiber are available, you can use nylon stockings (lycras). Use a piece of porous sponge as pre filter.

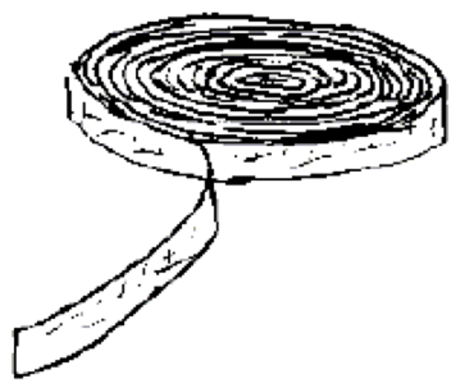
How to build the filter :
Cut the bottom of the bottle with a knife or scissors.
Then, with a strip of polyester cloth, make a roll with the same diameter as the bottle, and put it inside the bottle, pressing it . The water to be filtered passes through the cloth, and dirt remains therein. When waters are too dirty, this filter tends to be quickly obstructed. In order to increase its capacity, on top of the roll arrange a round shaped sponge which will absorb the bigger particles. When you wish to clean the filter, simply hold the roll in its place inside the bottle, and blow some air through the bottleneck. Instantly the air will be ejected, mixed with dirty water. The sponge must be washed separately.

These filters can also be improved.
When water has an unpleasant flavor even after it has been filtered, odors can be eliminated letting water pass through a carbon filter.

For carbon filtering,







it is most important for water to be pre filtered. So then use two similar filters separately. The carbon filter is slower, but it considerably enhances water. To have always "super filtered" water available, this combination of slow filter is arranged on an iron frame (iron for construction) or a wooden frame.

It is most important to maintain these filters always moistened, so a microbes' film can be maintained on top of them. This film increases the retention capacity of the filter.

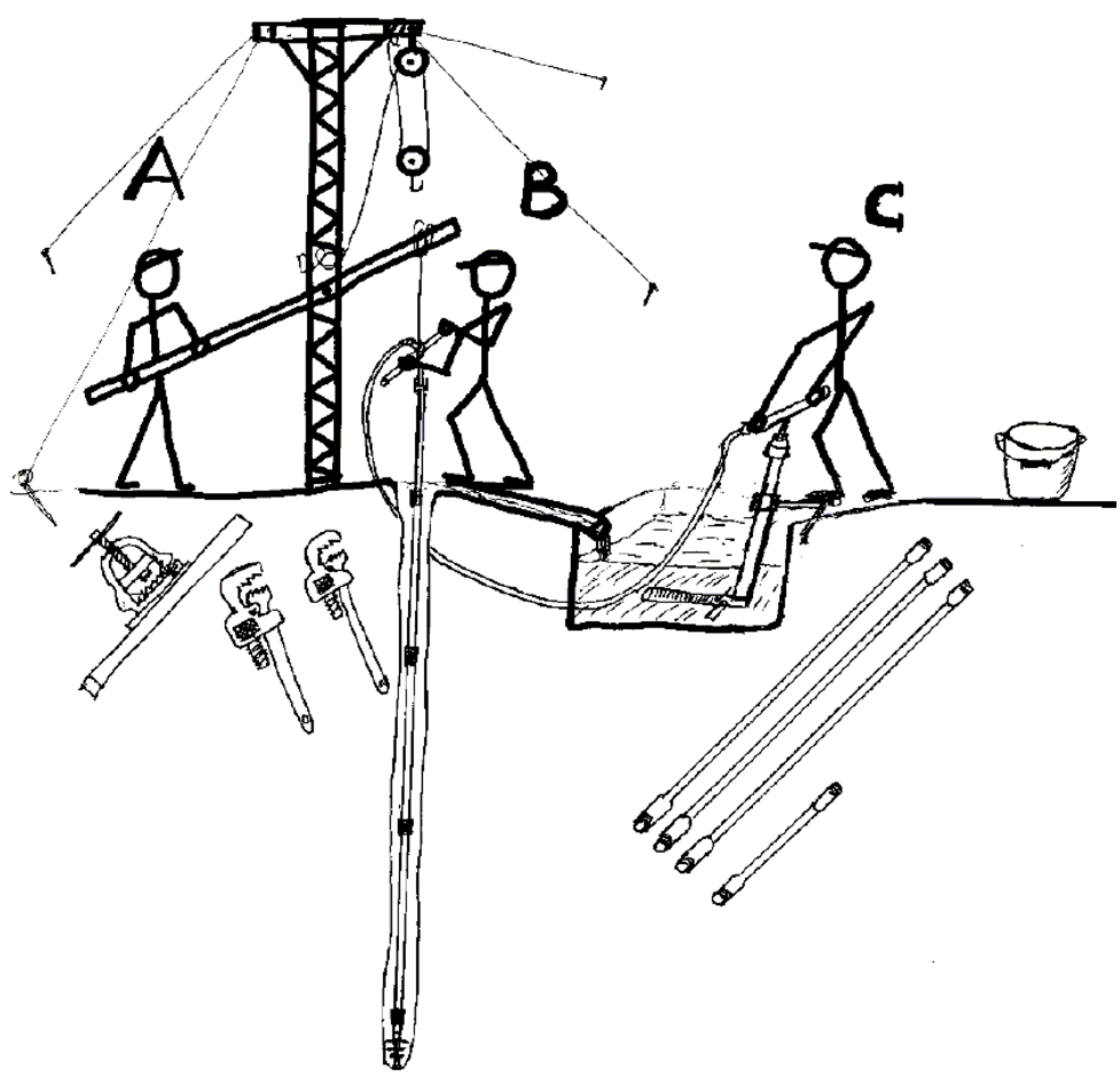
First let water pass through the simple fiber filter; usually this will be sufficient. If water continues to have an unpleasant flavor, then merely change the bottle and let it pass through the carbon filter.

With a small dose of chlorine or another disinfectant (e.g. lavandina) water will have the same flavor like in the cities.

After half an hour, you will have drinkable water.

Remark : our health will not be affected if the chlorine flavor is rather intense. Disinfectants such as lavandina are not insecticides, and their raw material is only salt and water.

EMAS manual deep drilling (washing)



With this drilling method you can attain down to 100 meters depth in soils of fine material which do not contain stones. The drilling has only 2 inches diameter. The average yield of these EMAS wells is 1 liter per second, that is to say 3600 liters per hour.

In Bolivia, the price of each meter / well including water jackets and the pump, is about 6 Euros/Dollars.

This drilling system is also very useful in soil survey, for example when you expect to find a weak aquifer and subsequently you excavate manually a wide well. It is also useful for setting up foundations, highways and in mining.

With this system you can obtain profit from aquifers of very fine sands without the risk of introducing sand into the well, and thus damaging the pump. For the filter, instead of gravel, we use a sleeve of synthetic cloth with different texture. In order to achieve an adequate activation through this synthetic cloth, the well is recovered by means of a reverse ram, and not - as usual - with compressed air. This ram allows extraordinary pressures and depressions necessary to initiate the flow towards the well.

Three persons can carry out the drilling works. Usually they progress 30 meters per day. The weight of all the equipment does not exceed 200 Kg; therefore it is adequate for places where access is difficult.

Tools needed :
- A 4 meters high derrick made of iron for construction. The derrick operates as a crane to introduce and remove the drill pipes, and as support for the balance. The derrick is fastened with 4 tension rods. Besides, use a lever with its shaft, a small stick to pull the rope; one or two pulleys and a resistant rope .
- 60 meters of drill pipes = 20 bars, 3 meters long, and two pieces 1 meter each, with 1 inch reinforced nipples. Also, a bit in place and another one for spare. One or two holders, 7 meters of a 3/4" hose, and a mud pump.
- As minor tools you need a pipe press to fasten the drill pipe when screwing up and unscrewing its pieces, 2 pipe wrenches, a piece of wire mesh to sift mud, two buckets and a steel brush.

Person A is in charge of raising the pipe with the bit between 10 and 40 cm, and drops it as strongly as possibly, so that the tooth of the bit are embedded to the ground. Usually you obtain about 20 strokes per minute. It can be raised with a lever or with a stick with a rope that goes through the pulley at the derrick. When starting you use the pulley, and after about 10 meters, the lever. Deeper the well is, longer the lever should be.

Person B is in charge of drilling. Once the tooth of the bit are embedded to the ground, he turns it around once; thus the tooth tears away the material and mixes it with the drilling liquid.

Person C pumps liquid into the well, by means of a manual pump, in order to stabilize the walls, maintain sand grains afloat and expel the drilled material. The liquid, which consists of water and clay, is ejected from the pump, passes through the hose, goes into the pipe though the holder, goes down inside the drill pipe, is ejected from an orifice at the bit, mixes with the drilled material, goes up - somewhat thicker - to the upper hole and falls down again into the mud well, wherefrom a new circuit begins. It is most important to adapt the density of the drilling liquid to the material of the soil being drilled. When clay is being drilled, water not dense is used, and when sand is being drilled, you need heavier water. Usually this liquid forms itself when drilling an argillaceous soil, but there are very sandy places where one has to prepare the mud, manually mixing clay with water. The EMAS system does not use bentonite.

Once one meter depth has been drilled, you must add another 1 meter pipe. Then you will change the two 1 meter pieces, for a pipe 3 meters long. Inside the drilling hole, only 3 meter pipes will remain until the drilling is over.

Drill pipes are 3/4 inches galvanized iron piping with 1 inch screw thread nipples as reinforcement.

Once the desired aquifer has been attained, and having penetrated therein about 4 meters, start to wash the well. For this purpose, instead of muddy water, clean water is injected into the well. From the bottom, water is ejected upwards. When the water ejected is clear, it means that the well has been washed. Then, one by one, unscrewing, the drill pipes are removed, using the pulleys as cranes, and the press to fasten them when unscrewing.

The pipe setting of the well consists of the filter and the pipes of the water jackets. Usually, 1 1/4 - 1 1/2 inches pipes are used, whether sanitary pipe, or class 15 bar PVC. The filter is a pipe of the same water jacket, in which grooves are cut with a saw. To prevent sand from penetrating into the well, arrange a synthetic cloth sleeve on the grooves.

Once the drill pipes have been removed, the well piping is put in pipes, first embedding the filter with its plug, and then the piping of the jackets. Then the well is washed for a second time, now introducing a 1/2" pipe to the jacket. Pumping clean water into the well, the filter cloth is washed; remainders of clay may have caused it to be blocked, when being introduced into the well.

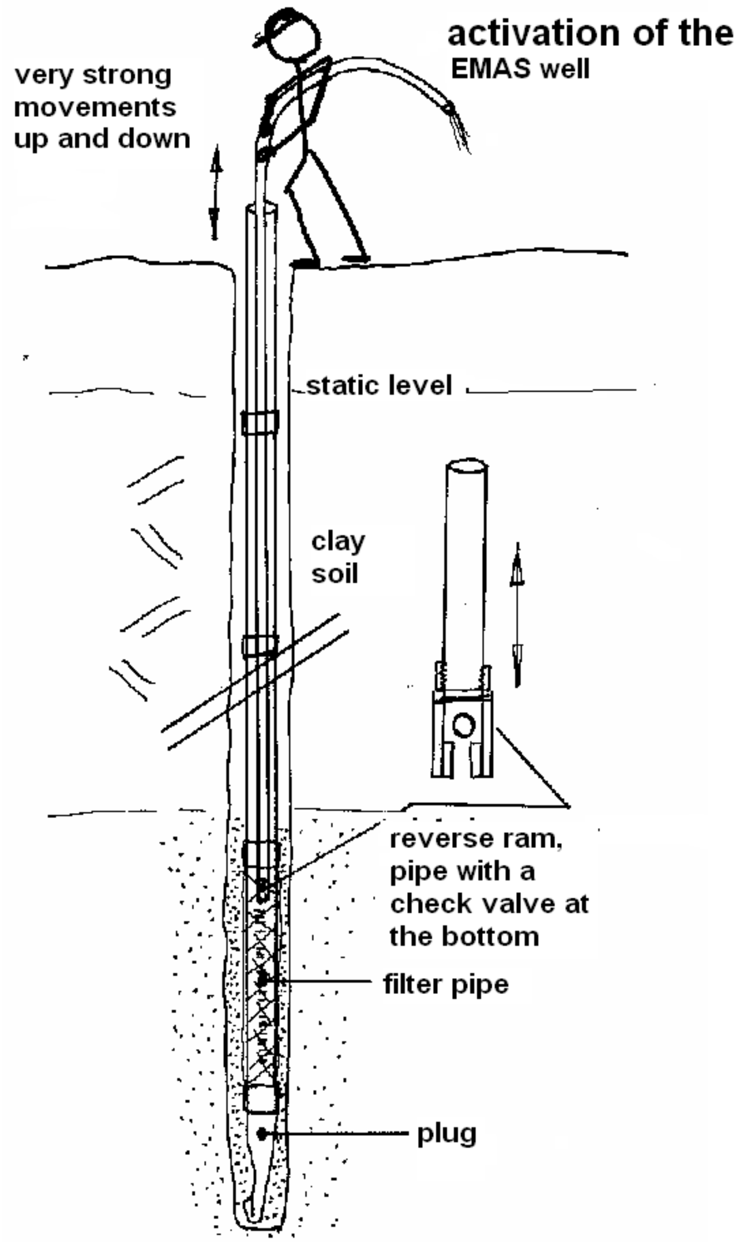
Then a bucket of sand is spread inside the well, in order to fasten the filter, and to fill the space between the wall of the aquifer and the filter.

It is worth mentioning here, that many different techniques exist in EMAS drilling. Along the years, drillers have experiences which are specific for determined soils in their regions. There are several kinds of bits, designed for different soils. For cemented and very hard soils, sharp ends with diamantine are used; for sand and clay, classic forms are steel sharp end tooth and lateral beaters.

Sometimes a check valve is arranged on top of the bit, and work is performed in reverse, pouring clean water into the hole, and removing the material through the drill bars, most of all when the phreatic level is too low and you find cemented material. When you find a spurting aquifer, the treatment differs even more .

When you don't find a reliable aquifer, then you carry out a provisional test (with the reverse ram) every time you reach a determined progress in the drilling, and sometimes in theses cases a long filter is arranged, reaching almost to the top. When the well production is very weak, so it does not allow a normal pumping, and if the phreatic level is not too deep, then you arrange a compensation tank shortly below this level, manually excavating around the drilled well.

The last operation when drilling an EMAS well, is to activate the well. While drilling, a layer of clay has adhered around the sand of the aquifer. This clay can obstruct water inflow to the well, and it has to be removed. Usually, compressed air is injected down to the bottom of the well, so that its strong bubbles may drag down the clay. But when a synthetic filter is used, it does not operate satisfactorily, and besides, an engine and a compressor would be needed.

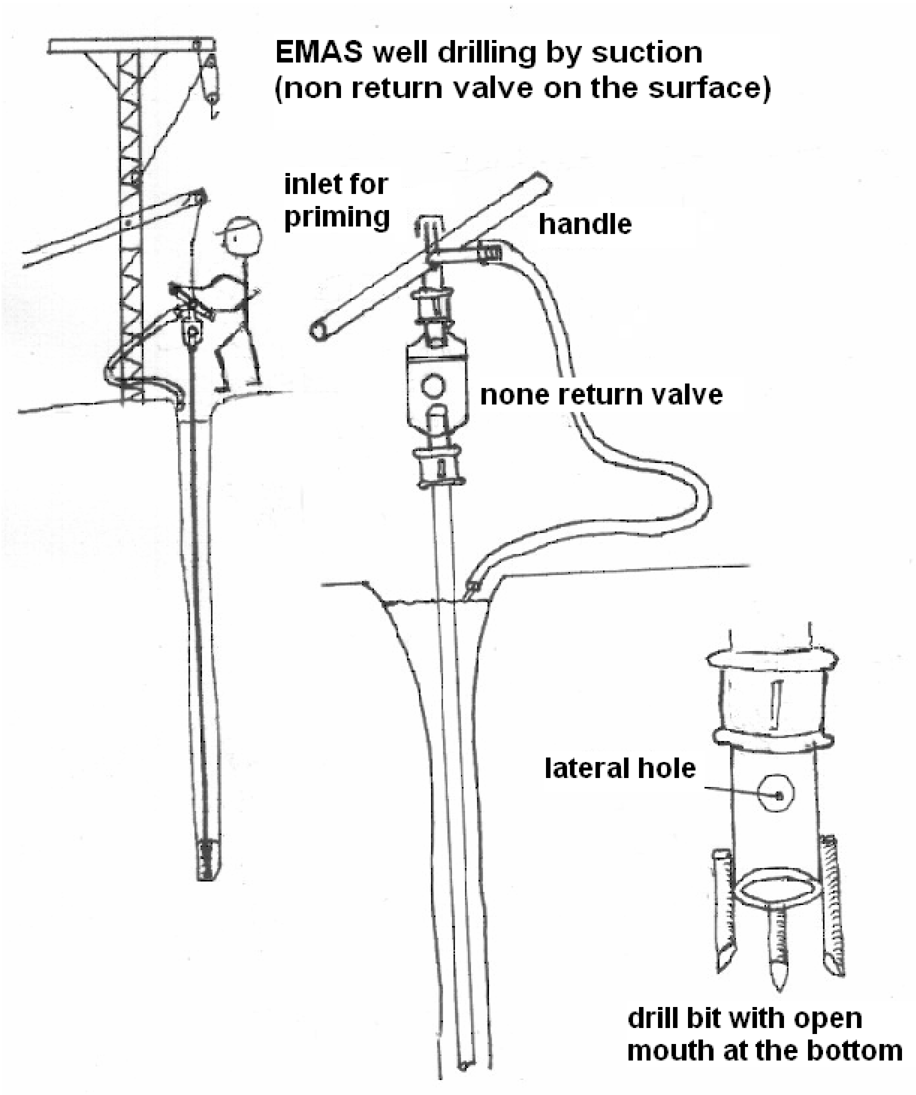


The system of the reverse ram is simpler and much more effective. Simply, a 1/2" pipe is introduced into the well, with a check valve at its bottom. As a check valve, we use a piston valve of an EMAS pump which can be locally manufactured. Quickly pulling the pump in and out, about 40 cm, you obtain the effect of a reverse ram, and water flows upwards inside this pipe. At the same time, at the bottom, strong pressures and depressions are formed due to the ram; this makes the clay adhered to the wall of the aquifer pass through the sand and the cloth, towards the well, wherefrom it is suctioned by the reverse ram.

Different materials may be used as platform for an EMAS well.
An old tire is almost indestructible, and besides it has no cost.

EMAS drilling system by suction

Whenever thick sand and little stones or pebbles make difficult to progress in a normal drilling (washing) then the drilling method is changed, using the suction system. As long as the pebbles do not exceed the size of a grain of corn, the same components of the classic EMAS equipment can be used, simply adapting a check valve below the holder. But if pebbles from the ground have a size bigger than 2 cm, you must use other bars of larger diameter, and a major valve. In the normal system (washing), the drilling liquid should be strongly thickened to be able to carry pebbles, which is not always possible.

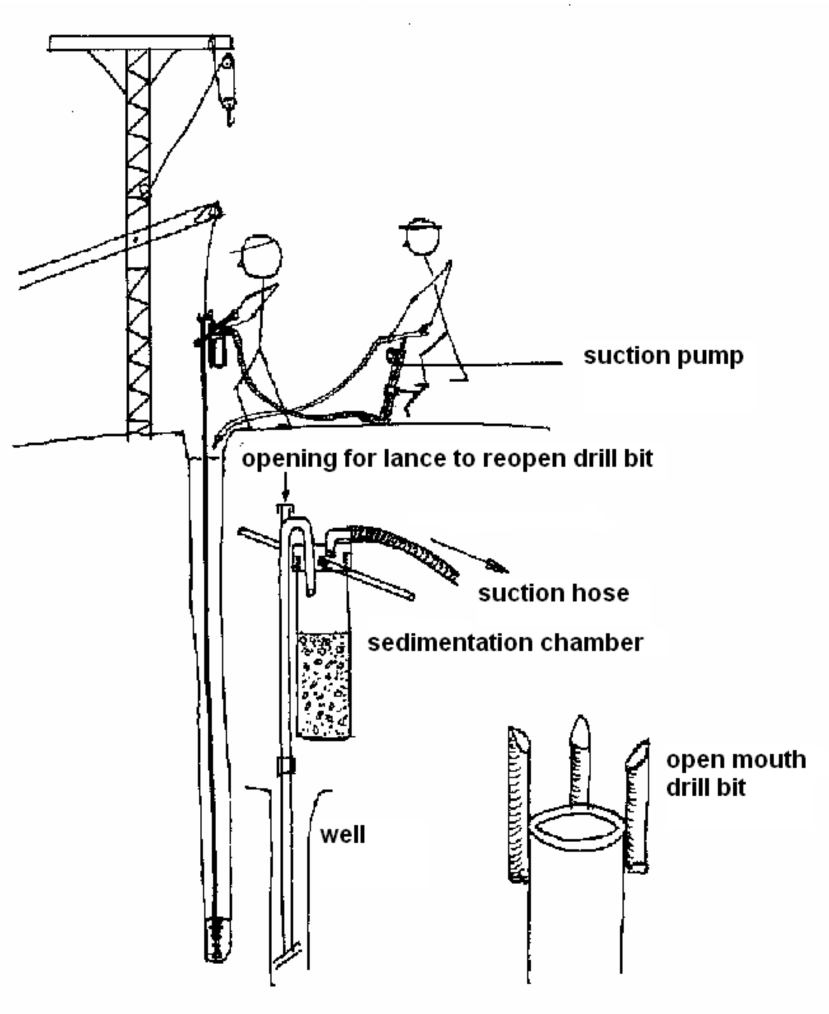


Another form of extracting thick materials is increasing the flow speed of the liquid; this is obtained through the suction system, since the flow area is smaller. In the washing system, the liquid is pumped by the bar up to the bit, and then it goes upward with the material pulled out between the bar and the well wall (the well overflows). The suction system is opposite; in it, the liquid goes downward by the well being drilled, but it goes upward with the material pulled out from inside the bar. The well being drilled must be always full of liquid; thus the depression of the suction only needs to surpass the height between the ground and the holder. To initiate the suction vacuum, the valve has to be lubricated with drilling liquid. The advantage of this technique is that no pumping is needed, since the liquid goes upward itself, by the motion of the bar. Also, it does not need much control regarding the quality of the mud (drilling liquid).

When deeper wells are being drilled, and during several days, you will always need the mud pump when introducing again the drilling bars. In soils of fine material, this system allows depths down to 100 meters (generally in combination with the washing system).

Another variant of the suction drilling is a vacuum produced by the mud pump itself. Instead of its sifter, a suction hose is connected to the mud pump, and a small liquid container at the upper part of the cylinder, to prevent the pump from suctioning air. The other end of the suction hose is connected to the sedimentation tank. The sedimentation tank is screwed with the drilling bar, and it is also the holder.

When pumping, a vacuum is formed at the cylinder of the pump; it is transmitted to the sedimentation tank through the suction hose. This vacuum continues to go downward inside the bar until reaching the bit, and allows to suction the material pulled out; it goes upward inside the bar, and falls into the sedimentation tank. There the heaviest particles settle, such as pebbles and thick sand.

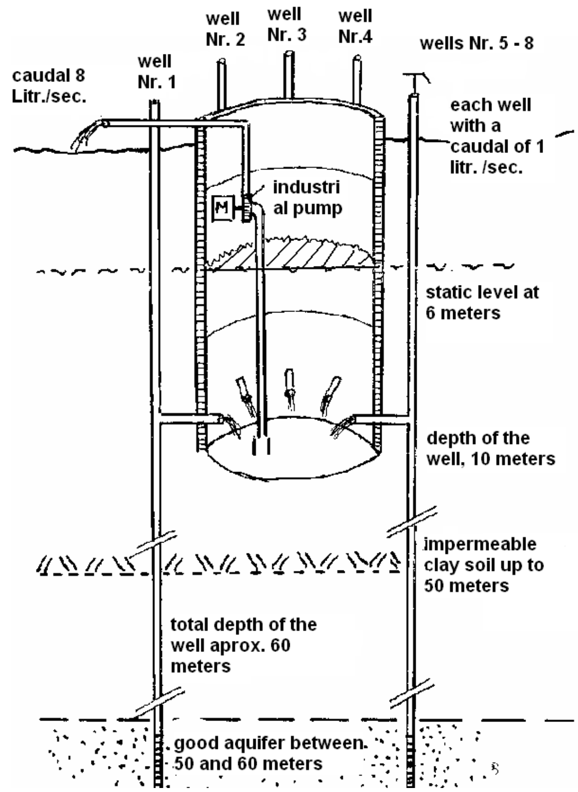


Only the liquid is ejected by the outlet, and once more it goes into the well being drilled.
For the suction to achieve its maximum yield, it is most important that the well being drilled is always maintained full of liquid.

When a big stone obstructs the sharp end of the bit, you can brake it or set it apart using a plain iron spear, which is introduced into the drilling bar by the unblocking orifice. Like this, it is not necessary to remove all the drilling bars in order to unblock the bit. When pebbles have a diameter bigger than the one of the drilling bar, you can use larger bars. However, this would mean an extension of the standard type, its weight would be increased, and the transport would become more complicated.

With this system, progress is slower, and it depends on the granulation of the soil, but it has its limitations when you find big stones. The depth is limited to about 30 meters.

EMAS multiwell



EMAS appropriate and inexpensive technologies are not only offered to provide personal dwellings, but also for a network of drinkable water for the community.

Survey is usually the first step; it means the investment being made to find out at what depth water will be found, if it is of good quality, if the aquifer allows a good volume, and - also of interest - the depth of the static and dynamic levels. You will find no cheaper method than an EMAS drilling.

If the aquifer is good but quite deep (more than 20 meters) the static level is high (about 6 meters); during the first 15 meters the earth is argillaceous and compact. Then the most adequate solution is the EMAS multiple well, most of all when the community is distant and its access is difficult, what would considerably increase the cost of a motorized drilling.

As you can observe from the drawing, first a deep exploration well is drilled. In case results are positive, a series of other wells are then drilled, forming a circle. The distance from one well to the other must not be less than one meter. Then, in the middle of them all, a well is excavated with traditional lining down to 3 - 4 meters below the static level. Since the material is waterproof (that data is known from deep drilling) there will be no problems of intense water leakage when excavating. Once the manual excavation of the wide well has finished, you look for jackets of the wells drilled, and you arrange a forking to the excavated well. Then each well drilled drains its water to the large well, and together they quickly fill it up the static level.

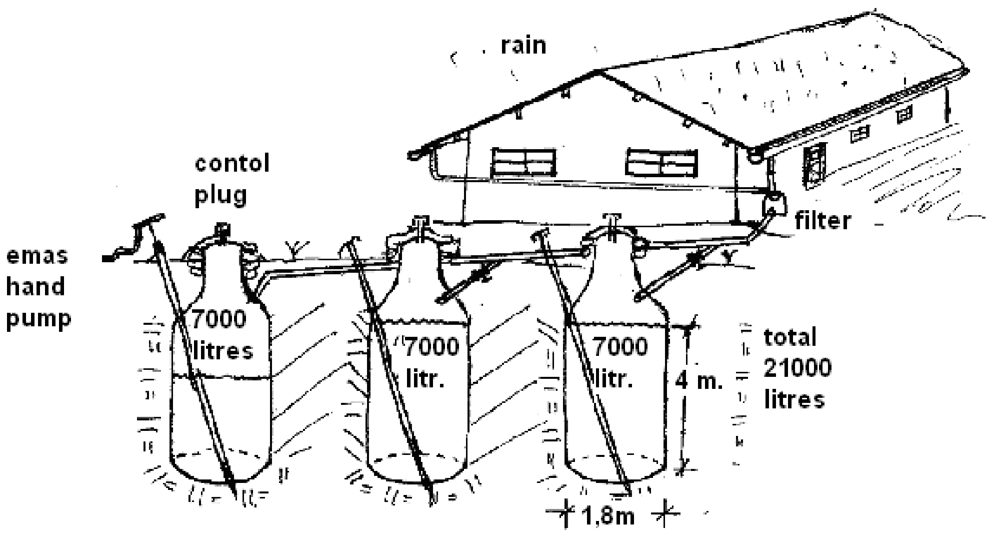
The last step is to set up a motorized pump that ejects water from the excavated well. Its volume is approximately the volume of the first well, multiplied by the number of satellite wells.

Another great advantage of this method is that an industrial pump can be set up, with a higher yield than pumps for wells drilled with several rotors. This will be shown in a considerable saving of energy. Practically all the work has been performed by the community.

The investment and operation costs are low. The community identifies itself with its work. Less dependence on spare parts exists, because industrial pumps are almost universal. The system encourages similar works, because people do not need to beg from institutions that render services of motorized drilling. In summary : you obtain the same volume of a motorized drilling, for a much lower cost. Besides, operation costs are lower.

EMAS pattern for rainfall impounding

At places where no hydric resource is available, such as a spring, well, river, brook, lake, irrigation channel, etc., the only solution left is rainfall impounding.



This system is not at all new, since 2000 years ago, the Israelites used to supply cities such as Mazada, located at the desert.

Few places exist in our planet where a rainfall impounding is not applicable due to complete lack of rain.

The roof

Roofs with metallic plates, roof tiles, cement fiber and reinforced concrete serve to collect water. Metallic plates have the advantage that they do not need a significant gradient, and they do not absorb water, like roof tiles do.

Roofs made of straw or branches/leaves are not appropriate, because they give an unpleasant flavor and color to the water.

Water volume

With an annual precipitation of only 20 cm, which is considered semi-desert, 20.000 liters fall on a 10 x 10 meters surface.

If we take a family formed by 5 persons, and an average consumption of 10 liters per person/day, then the daily consumption is 50 liters.

Dividing 20.000 liters by 50 liters per person we obtain 400 days for water supply, that is to say, more than one year.

The water volume available depends on the area of the roof, and on the volume of rainfall. At places where rain is scarce, a larger roof is needed than at places where rainfall is abundant .

The formula of water volume in liters is :

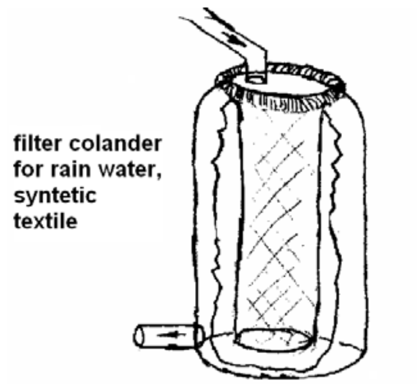
Length x width of the roof (in meters) x the amount of annual pluvial precipitation in millimeters :

$V = l \cdot w \cdot h$

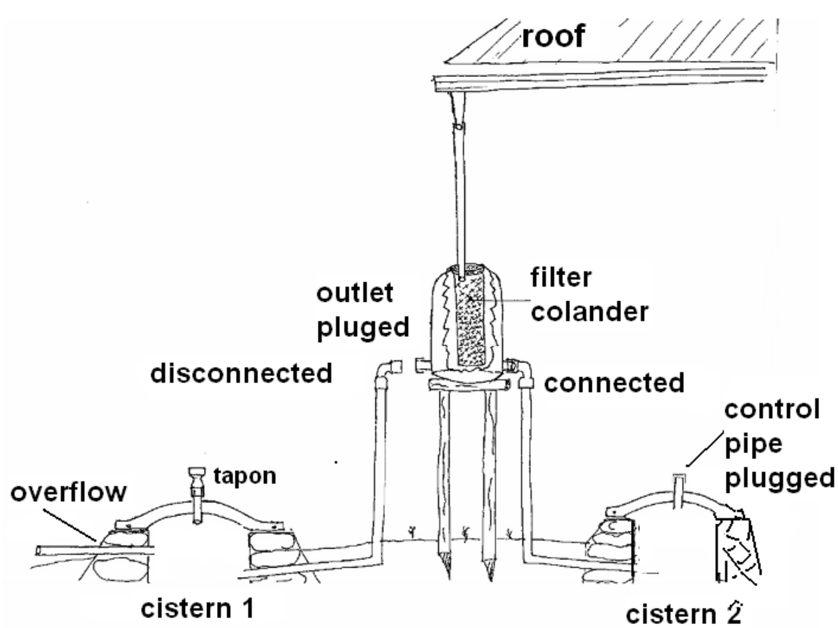
Many places in Latin America have rainfalls of about 500 millimeters per year.
When the house is small, 5 x 6 meters (that is to say 30 square meters), with 500 mm annual precipitation, it receives a rainfall of 15.000 liters on its roof; this is a sufficient amount for a family formed by 5 members.

Collection
Roof gutters are used to collect water from the roof. There are roof gutters made of different materials such as PVC, zinc plates, bamboo, etc. It is important for the roof gutter to absorb torrential rainfalls.
To prevent obstructions due to leaves, the roof gutter must be cleaned periodically.

The filter
Little birds soil, leaves fall and the wind deposits dust on the roof. If these particles get into the cistern, they rot and emit bad odors. At the same time, many germs are formed which are not harmful for man, but which undoubtedly are indicators of pollution. Therefore these substances must be kept back with a filter. Experience has shown that a fine strainer will be adequate. As a filter box, a pitcher is used with a 1 - 2 inches outlet, according to the size of the roof. As filtrating screen, the cloth of a synthetic blanket is used, from which a bag is sewn, its bottom round-shaped. At the fold on its upper part, an iron ring or a galvanized thick wire is arranged. The ring must have a larger diameter than the pitcher's nozzle, so that the bag hangs on the tank and does not reach the bottom.



It is advisable to clean the bag every 3 months.
Almost all traditional cisterns have no filter. To keep out garbage, the first part of the rainfall is deflected; generally it drags most part of the garbage. However, there is always a certain amount of dust and leaves inside the cistern. When you are not careful and forget to arrange the deflection again, all the water is spoiled and the cistern is emptied.



A roof impregnated with smoke gives an unpleasant flavor to water; therefore it is most important for the kitchen to have a tall chimney, or else choose a roof where no smoky tiles exist.

Results of recent studies

made in Paraguay regarding abrasion of heavy metals in zinc plated roofs are that practically no traces are left, and that this danger does not exist.

EMAS Cisterns

Among the many shapes and types of cisterns available, the EMAS cisterns excel for their easy construction, low cost and life span. They are underground tanks coated with a thin layer of cement mortar and made waterproof with a pure cement whitewash. As an average, their volume is 4000 - 8000 liters; generally 2 - 3 cisterns are built for a house when it is supplied only from pluvial waters. Normally an EMAS pump is used to take water upward to a ferro cement tank and to be distributed at the dwelling.

Distribution to the cisterns (underground tanks)

Water can be conveyed from the roof to the filter through a 1 1/2 - 2" sanitary pipe according to the size of the roof. From the filter to the cistern, a smaller measure will suffice, since the volume of the filter pitcher compensates short increases during heavy rainfalls.

To connect the cisterns, we recommend the shape shown in this figure. It is wise to fill only one cistern every time, and leave the outlet via of the other cistern with a plug. By means of the connection shown, the other one can be connected in a few seconds, pulling out the plug and switching the bend. It is advisable to arrange a wire mesh at the external sharp end of the overflow, to prevent insects and mice from getting inside.

Exceptions for the interpretation of bacteriological analysis in pluvial impounding

Since we are dealing with a rainfall impounding from the roof of a house, and most users do not use chlorine to disinfect water, it is more than probable that germs will be formed in the water during its storage. When the quick filter is not used correctly, organic matter may get into the cistern and form a sediment that slowly mineralizes, giving bad flavor to water and, most of all, leaving many germs. Even correctly using the filter, it is a fact that after a rainfall, it contains germs coming from the roof : they may originate from excrements of little birds, small lizards, flies, etc.

According to the rules set by the WHO (World Health Organization) drinkable water must not surpass a determined number of germs, it must not have e.coli or coliforms, but the base for all these requirements is that drinkable water must not be harmful for health.

In pluvial impounding, without the use of chlorine one cannot achieve the above mentioned indicators (few germs, no e.coli or coliforms), but it can be guaranteed that water is not harmful for health, since those indicators themselves are inoffensive and practically no pathogenic pollution exists, since animals with potential illnesses for man do not excrement on roofs (big mammalians).

Therefore, other parameters must be used when interpreting a bacteriological analysis of pluvial waters stored during months in underground cisterns (A point to be evaluated in the pilot project).

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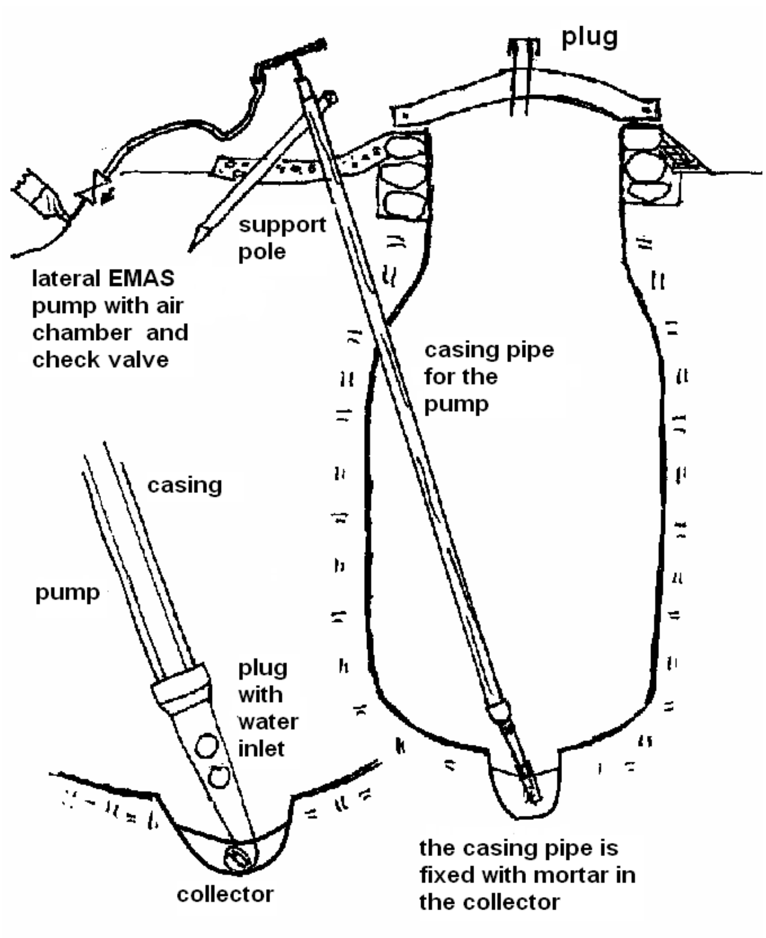
Multiple uses of a cistern
The use of an EMAS cistern is multiple. It may serve as a stand-by reserve of a well that conveys water only during the rainy season. It may serve as a deposit in case water supply through a network is most irregular. When salt water or polluted water exists in the well, which may still serve for washing, bathing or other uses, rain water stored in a cistern solves the problem of drinking and cooking. Several cisterns, in their classic shape, serve to store pluvial waters which are the only form of supply. The cistern is also used as treatment tank, for instance for flocculation of turbid waters from a ravine flow. Sometimes it is used to store sewage waters which are subsequently used for irrigation, after being treated in septic chambers.



Building an EMAS cistern, vertical pattern
Begin the excavation with a reduced diameter, 0,8 meters, until reaching firm soil, but at least one meter deep. Then the excavation is enlarged until 1.40 - 1.80 meters. The reason for the reduced diameter at the neck of the cistern is because of the cover. A big cover, with a 1,8 meters diameter is expensive to build, and difficult to handle. Instead, a cover with only 1 meter diameter weights less, it is easier to build, and it is quite inexpensive because of its arched shape, given that it uses very few iron bars. The depth of an EMAS cistern practically has no limit, but usually it is as deep as the length of the ladder, 3 - 4 meters as an average. Once the desired depth has been reached, begin the excavation of its bottom, shaped like a half ball. This makes sediments settle at one point only, wherefrom it is easy to remove them with the pump.

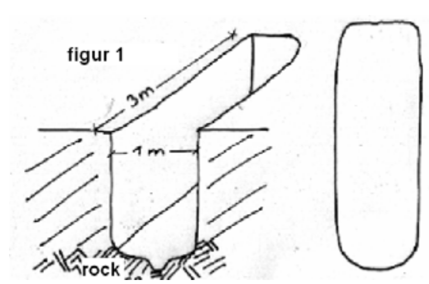
The curbstone
When the excavation is finished, the curbstone is set up, beginning with a foundation around the cistern's hole, and about 30 cm deep. On this foundation, a curbstone is set up of about another 30 cm, using stones and mud, or only mud. On the moistened mud you set a cement layer of about 3 cm, to make it solid and waterproof.

However, before doing this you should set up the intake and overflow piping. For a roof of up to 50 m2, a
1 1/4" pipe will do A plastic millimeter screen is tied to the overflow pipe to prevent insects or other animals from getting into the cistern.

Mud cakes
When the curbstone is finished, start setting up the mud cakes. Their function is to form a clean and solid layer, on which you may lay the cement whitewash. Only a pure cement whitewash can guarantee to be waterproof. Increasing the thickness of the mud cake (except at the bottom of the cistern, where the ladder is arranged) only increases the cost, but it does not improve the quality of the cistern. The full thickness of the mud cake is about 2,5 cm. Often people insist on having a thicker wall, arranging an iron screen or at least a hen house wire mesh. Truly, using more material will do no harm, but it is not necessary. Neither a hen house wire mesh nor an iron screen electrically soldered would resist a telluric movement. A thick wall would also crack. This experience has been learnt from traditional cisterns and tanks with walls of brick of reinforced concrete.

When excavating a stony soil, and holes remain where stones have fallen, it is preferable to cover them with mud made of the same earth left. It is better to use slightly dry mud. Then you prepare a cement mortar with fine sand. The proportion may vary between 1 : 4 and 1 : 5, according to the sand texture. With this mortar you plaster the first coat directly on the moistened earth. Its thickness is of approximately 1,5 cm. Once this mortar has aerated, lay the second coat with a proportion of 1 : 3. The second coat is thinner than the first one. It is important for all the plaster works to be performed without interruption; this means not letting some days go by between one plaster and the other, or between the whitewashing, because then the cement will not hold. During the second plaster, the wall is polished, but it does not matter if it is not perfectly symmetrical, straight or flat. For this task, the use of a slipper or a house shoe has proved to be most practical. Those who are not well acquainted with the use of a trowel should use rubber or oilcloth gloves and set the mortar manually. At the end of the plastering, the case pipe is arranged for the pump, with its plug.

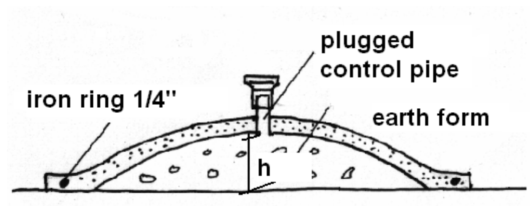
Pure cement whitewash
When the plastering is finished, wait about 12 hours to set the first whitewash layer. It is most important to always cover the cistern mouth with plastic when you are not working, to prevent the cement from drying. Whitewash is a mortar of pure cement and some water; it looks like toothpaste. It is laid on the wall with a brush or a thin broom. You should be most careful when laying a whitewash because it makes the wall waterproof. Even the smallest holes or pores must be covered.



Usually two coats are laid. 70% cisterns built by junior technicians drop water because the whitewash was not carefully laid. The inlet hole of the case is perforated with a knife at the floor level, but only when the cistern is finished and cement has hardened. The drilling must have a diameter of at least one inch. A little pit at the deepest point of the cistern helps to evacuate even the last drop of water. It is advisable to wait at least 5 days before filling the cistern, to prevent water having cement flavor.

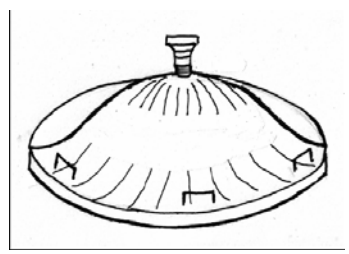
The cover

Different shapes of covers exist. EMAS casts its covers arched, vaulted. For its mold, a small hillock made of earth and covered with plastic or paper is used. The height of the arch is a fourth part of its diameter. This shape allows great resistance to pressure on its upper part, and it is most inexpensive because it uses no iron bars, except a 1/4" ring near its outward edge. To be able to pick up this cover, which is quite heavy, two holders are cast, tied to the i/4 iron ring. For a 1 meter diameter cover, cement must be 5 cm thick (larger diameter, more thickness). As its outward mold, a 1/4" x 2" platinum is used, or simply stones, earth, etc. on its edge. At the center of the arch or vault a short 1 1/4" pipe is cast, of about 20 cm length. This pipe is used to control the level and volume of water, and must be always plugged with a stopper made of the same PVC pipe .



hight = 1/4 diameter

Usually the cover is adjusted with mud on the curbstone. In exceptional cases you may also use a base of synthetic material, forming a ring of cloth or rolled up plastic. We do not recommend to adjust the cover directly on the curbstone, since it may not be steady and then be broken.



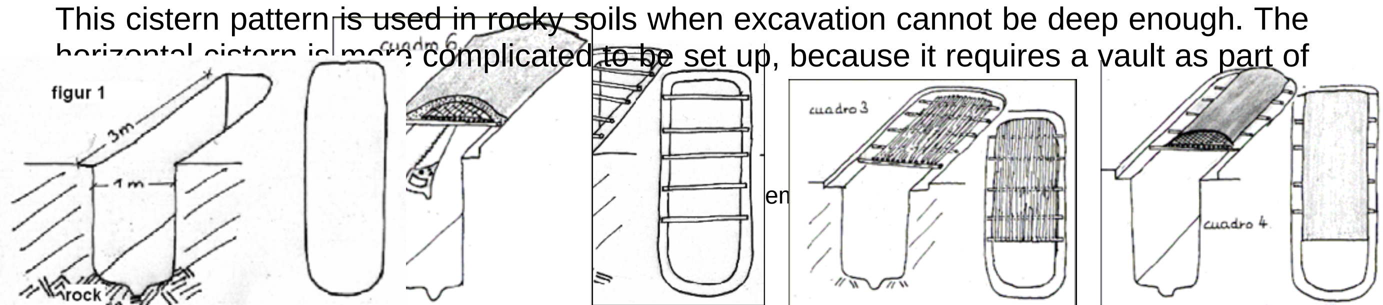
Setting up the pump; how to clean it

The pump is set up in a guide pipe which is at least one measure larger than the pump. This guide pipe allows to easily remove the pump for subsequent repairs or maintenance. At its bottom, the guide pipe has a stopper, cemented at the lowest point of the cistern; on top, it is compressed by almost one meter of earth; also, it is tied to a support stick.

Water from pumping gets into the guide pipe, at the cistern ground level, at the point where the stopper is, through a hole perforated with a knife. If for any reason sediment appears at the bottom, for instance in a flocculation cistern (much better in the vertical pattern) with this system it is easy to remove it. Simply take off the pump from the case and introduce it down to the bottom through the pipe at the center of the cement cover. Then you pump, suctioning the sediments from the level, always changing a little the position of the pump above the floor. This same technique is used to clean swimming pools.

Building a Horizontal cistern

This cistern pattern is used in rocky soils when excavation cannot be deep enough. The horizontal cistern is more complicated to be set up, because it requires a vault as part of



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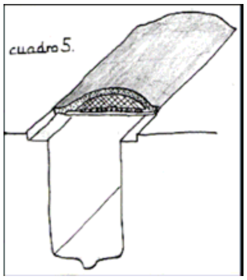
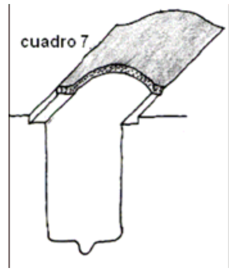
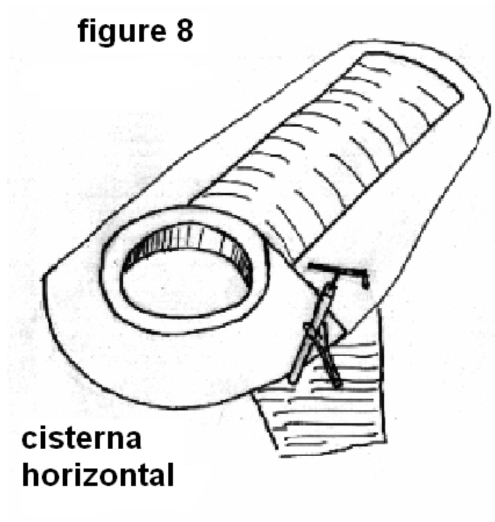
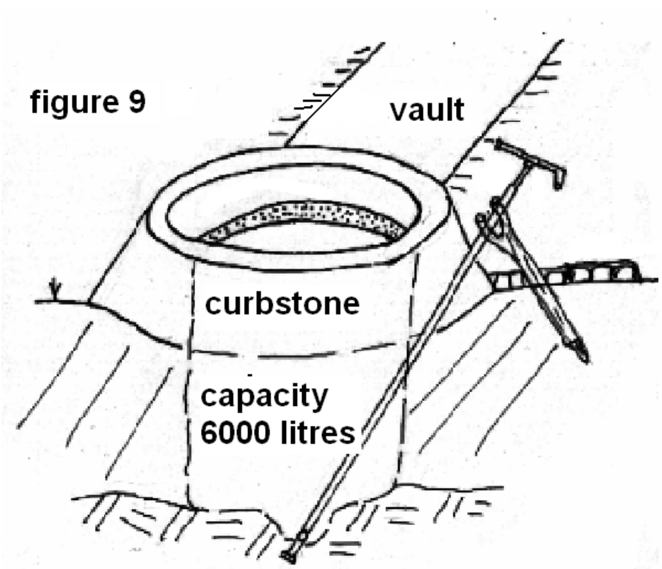




Of course flat tiles could be melt and cover the cistern, but the technique we show here is cheaper and simpler because it requires no iron bars and it is self supporting. First you excavate a hole with the shape of a ditch. For a guide we propose 3 meters length and one meter width. Depth may vary from one to 2,5 meters. When digging, it is important to leave an inclination at the bottom of the ditch, sidewise. Subsequently, the pump and the cover will occupy this space. To set up the vault, start as shown on Figure 2. The edge around the hole must have approximately 20 cm depth and about 30 cm width. Then set up 5 sticks as thick as a fist. On these sticks, set up thin branches, stalks, etc. It is important to cover only the area of the hole, and not the lateral deepening. Then arrange plastic or cement bags on the branches, and spread earth on them. This earth is formed for the vault mold. The curve is similar to the segment of a circle which height is equal to the fourth part of its width. On the earth mold, arrange papers or plastic, and on them, the cement mortar 1 : 3. To increase the thickness of cement, add some stones and mix them with the cement mortar.





Then cover the cement and let it harden. When 5 days have elapsed, you can cut the transversal sticks, starting with the inner ones. Then the sticks are dropped with the mold earth, and only he vault remains. The next steps are quite similar to the ones described for the vertical cistern.

Surface cistern

At places where it is not possible to dig, you can build the EMAS pattern surface cistern. Actually it is a classic ferro cement tank with the only difference that it is more compact, it has no foundation and therefore it is more resistant to fissures. Its construction is simple and most of all very inexpensive, since it does not require too much material or wood :

Materials: Iron bars : All iron bars are 1/4". Ten rings, 1,87 meters diameter (6 meter round shaped rods with 10 cm overlap make a 1,87 meter ring). For the base and the vault, use two 1,40 m rings, two 90 cm rings and two 60 cm rings; you also need 60 meters of hen house wire, 2 Kg of lashing wire, 400 Kg of cement and 600 Kg of fine sand.

Construction : To obtain the self supporting base, build on the ground a round shaped small hillock made of earth, the same as for an EMAS cover. Its diameter is 1,80 meters; its height : 45 cm. On this mold, arrange a plastic sheet; then set up a cage with the iron tools, starting with a ring at the base. Initially only 4 supporting beams are set up, on which the lateral rings are arranged, from 15 to 20 cm distant in between.

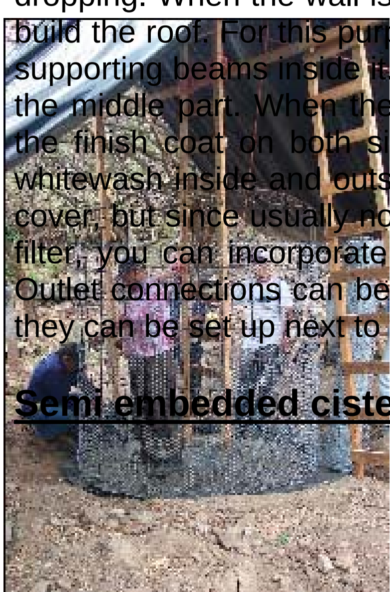
So the supporting beams are firmer, next to them provisional sticks are embedded, about 2 meters high. Then the remaining 26 supporting beams are arranged, 20 cm distant in between. All iron crossing joints must be tightly tied. Once this cage wall is finished, an iron wire is made for the floor and the roof, using the smallest rings. Then cement is cast for the floor with a 3 : 1 mortar.

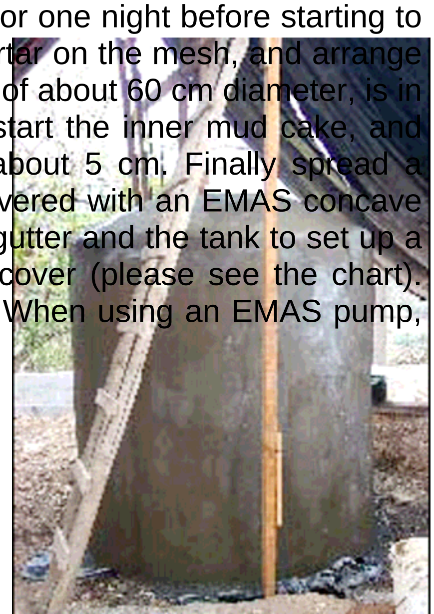
To be able to get inside and out from the tank while works are being performed, build the framework of a ladder; at the same time it will serve as a roof for shade, and as protection from rainfall.

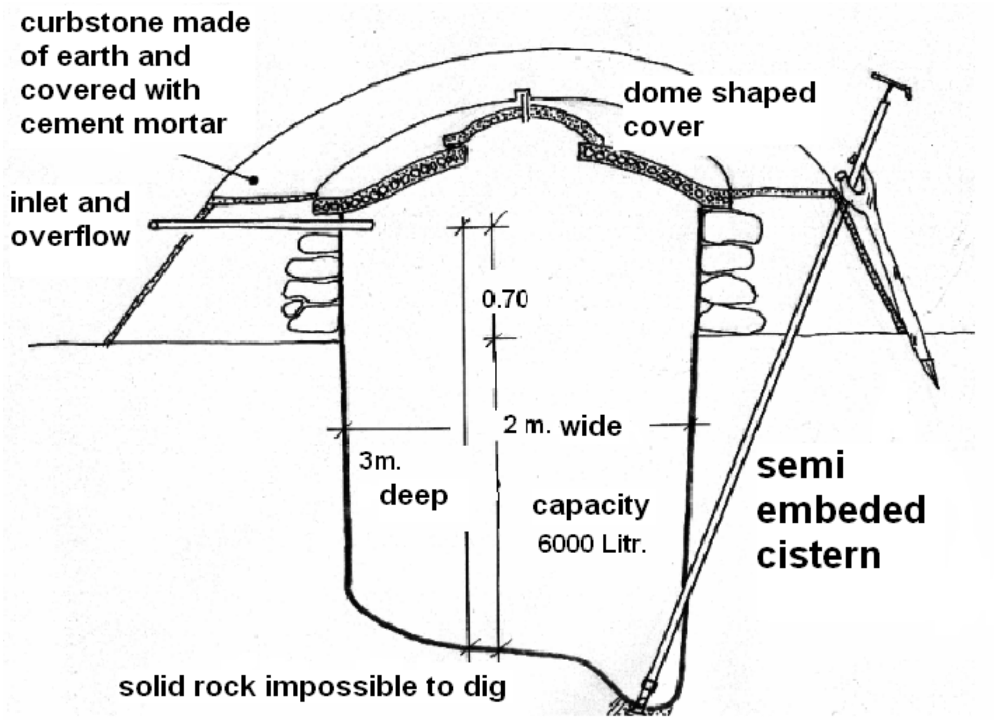
Once the cage is finished, as well as the cement floor and entrance framework with its roof, set 4 screen wire (hen house screen) arrangements on the cage. It is easier to use rolls of only 50 cm width, since they can be better applied . Tie the mesh to the iron bars. Its only function is to hold the cement from the mud cake, since for this kind of tank, no plank lining is used. Start from the bottom, spreading 3 : 1 cement on the mesh.

The person who is inside must hold a board against the mesh, to prevent cement from dropping. When the wall is finished, cement must harden for one night before starting to build the roof. For this purpose, simply spread half dry mortar on the mesh, and arrange supporting beams inside it. The round shaped intake hole, of about 60 cm diameter, is in the middle part. When the first external coat is finished, start the inner mud cake, and the finish coat on both sides. The wall thickness is of about 5 cm. Finally spread a whitewash inside and outside. The intake hole may be covered with an EMAS concave cover, but since usually no free space is left between the gutter and the tank to set up a filter, you can incorporate the filter to the same cement cover (please see the chart). Outlet connections can be arranged as the case may be. When using an EMAS pump, they can be set up next to the cover.

Semi embedded cistern



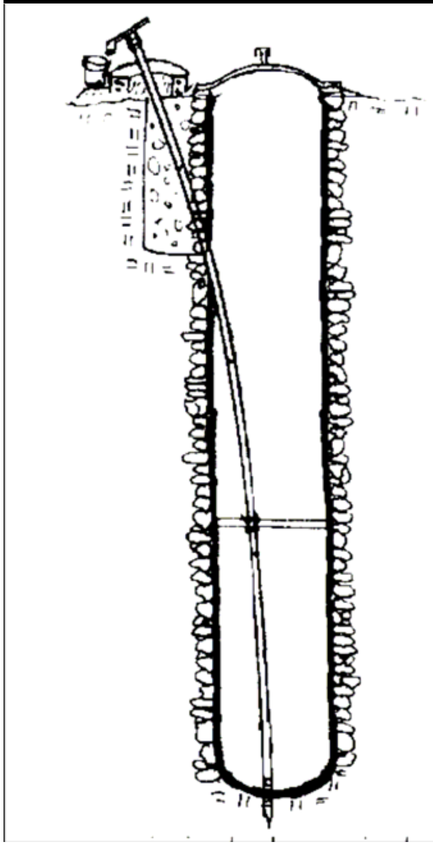




Sometimes an excavation is carried out for a deep cistern, and at three meters depth you find that a solid rock is obstructing it. The water volume it could store, due to its scarce depth, would not be sufficient. In this case the excavation can be enlarged up to 2 meters width, and raise a large earthen wall, tightly compact, and thus increase the effective cistern depth. The thickness of the wall depends on the height you wish to reach, and it must be at least 70 cm at its bottom if its height reaches 1 meter. For this system we do not recommend heights exceeding one meter.

The tile would be too heavy to cover this 2 meters wide cistern. In order to reduce its diameter, build a vault the same way as when setting up the vault, but leave a round shaped intake hole in the middle, of about 60 cm. Then cover this intake hole with a cement cover, as already explained.

Failed excavated well transformed into a cistern



This choice is offered if no water is found when excavating a well. Instead of work being lost in a useless hole, it can be easily transformed into a cistern with a high water volume. The steps to be taken for its construction are the same ones as described in the preceding articles. The situation is more complicated when the well has already been jacketed. You must see that jackets are pressure resistant, or that they are tightly attached to the firm earth of the wall. Otherwise, cracks will appear and water will be lost (if there are any cracks, use water with clay to obtain an adequate filling). If cracks have formed, due to pressure pushing the jackets towards the firm earth at the wall, it becomes necessary to spread a new mud cake coat inside. Then the cistern will be made waterproof.

If no appropriate roof is available nearby, a temporary watershed can be used, or the water from an occasional ravine. To obtain crystalline water from a ravine, a flocculation and sedimentation previous tank is necessary.

Advise to make it waterproof

Sometimes very small pores remain, or small fissures are formed at the cistern wall, whereby water runs. That is why the user must periodically control stagnant water. The easiest - and also the most inexpensive - way to do it, is to paint the wall with asphalt paint.

This paint is prepared melting asphalt stones and mixing the liquid with gasoline. You should be very cautious when mixing hot asphalt with gasoline, since the steam formed is highly explosive. Therefore this must be done only in the open air. You can also purchase this paint at local stores, already prepared. Undertakings use it for the maintenance of asphalt paving, or car metal plate workmen. You only have to ask for the most volatile diluting as possible; otherwise its drying would be too slow. Instead of asphalt paint you can use diluted paraffin or swimming pool paint. When painting the inner side of a cistern, great danger of asphyxia exists, due to poisonous gases that evaporate from the paint diluting. To get fresh air in shut in cisterns, breathe through a hose with its other end outside. You must always use a good ladder, and someone should stay nearby, to assist in case of emergency.

Disinfecting with chlorine

Disinfecting with chlorine (lye, lavandine, etc.) guarantees healthy water, free of microbes. A 0.8 milligram concentration per liter allows a long duration.

Following is a guide for its application. The value is multiplied according to the volume of the cistern. A spoonful has approximately 5 cubic centimeters. If the measures as indicated are slightly changed, this will not greatly affect. Another most practical manner is to pour chlorine until the flavor is similar to water from a big city.

If using 5% sodium hypochlorite, pour 16 ml for each cubic meter of its volume.

For instance, for a 5000 liter cistern, use 80 ml. When using 10% sodium hypochlorite, pour 8 ml for each cubic meter and pour this in a 5000 liter 40 ml cistern.

Final remarks : These types of underground cisterns have been designed for dry places, with compact earth. Vertical cisterns have also proved to be excellent in very sandy soils. No underground cistern is recommended for very humid soils or in soils with recent refills, due to the risk of landslide. The horizontal cistern is not recommended where frost penetrates more than 40 cm. Well understood, no tall trees should exist nearby, which roots may damage the cistern. Anyhow, the vertical cistern (the deep cistern) has many advantages for types which are not so deep, since when dealing with deep sites, roots are less harmful, the earth is firmer, no frost penetrates and less danger exists of surface infiltration.

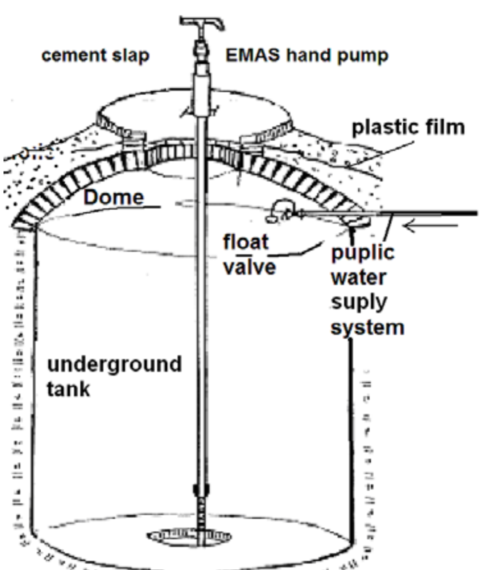
To store a good quality drinkable water in a cistern, it is always recommended to chlorinate it .

Supplementary Cistern

1 . where water flow is received through a piping, but is most irregular;
2 . where the well dries up in a determined season
3 . where no sufficient roof area exists for a good supply

1 . when water flow is received irregularly and at moments when you are away, you lose the opportunity to receive it, and then you suffer scarcity.

In this case the solution is to prepare a tank with a float valve. When there is water, the tank is filled and when it is full, the float valve automatically shuts. If water has a good pressure, it is convenient to build the tank above the highest faucet of the dwelling (shower or tap on the second floor). But frequently only a scarce flow is received and an elevated tank cannot be filled. Generally people use tanks and other containers with the disadvantage that water is polluted, even more when small containers are introduced to get some water.



The solution proposed by EMAS for this case is a ferro cement underground cistern, and a FLEXI pump.

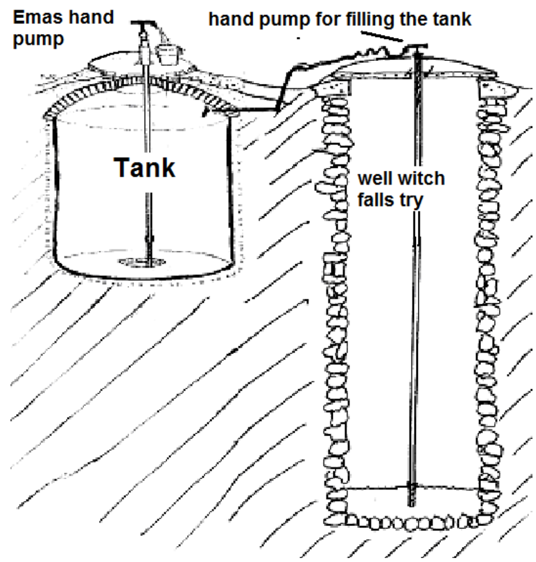
To regulate intake and prevent overflow, arrange a float valve. Like in small impounding from watersheds, a polyethylene oilcloth is arranged between the vault and the surface, so there is no infiltration of water spilled from the pump.

When electricity is available, you can use a small 200 Watt centrifugal pump.

2 . If the excavated well dries up

Some wells have enough water most part of the year, but they dry up during the low water season. It may become very expensive to get some water during those months, most of all when no other source is available nearby.

If the deepening had no positive result (excavating or drilling a root) the possibility exists to build a cistern near the well. It can be filled when the well receives a water inflow, and be kept as storage when the well dries up. In the cistern, you can also add water from a roof nearby.



The FLEXI pump makes possible to pump directly from the excavated well to the cistern.

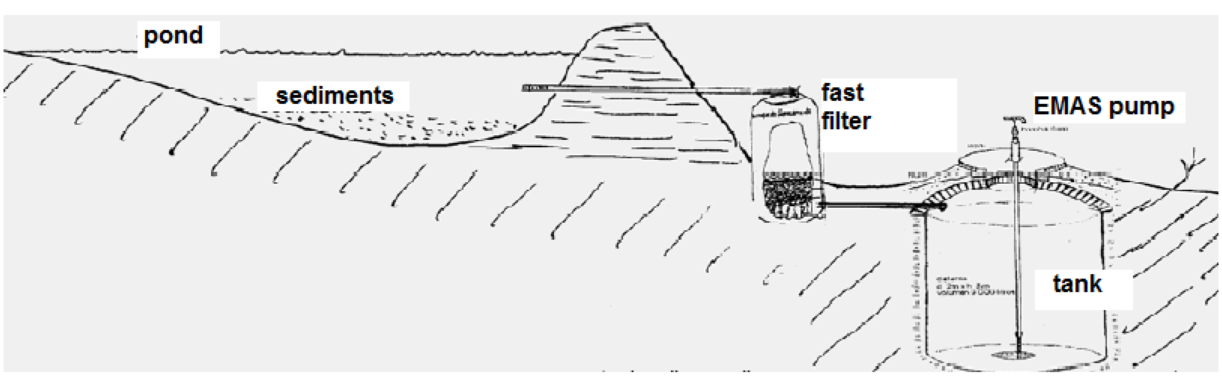
What to do when no roof or well are available

In this case, a cofferdam is built, enclosing a ravine or a rain water flow. Most of all in mountainous areas, this system is most feasible. When it rains, water runs by the ravine and it is stopped at the ravine. Sand and earth settle down. The lagoon is only temporary, and in a few days water is lost in the subsoil, or else it evaporates. Therefore, water must be conveyed to a cistern through piping; there it will be stored until it is used.

The filter is most important before inflow to the cistern. If earth or organic matter get into the cistern, they will rot, forming sulfur combinations with unpleasant odor.

Using a quick filter of polyester fiber (EMAS filter) or a slow sand filter (it needs much more space) almost all organic matter is eliminated and if some turbidity still exists, it settles in the cistern, causing no fermentation.

Finally, do not forget to chlorinate water. For these cases we recommend to use a high concentration, 1 milligram per liter (for a 9.000 liter cistern, a small bag of chlorine or lavandina).

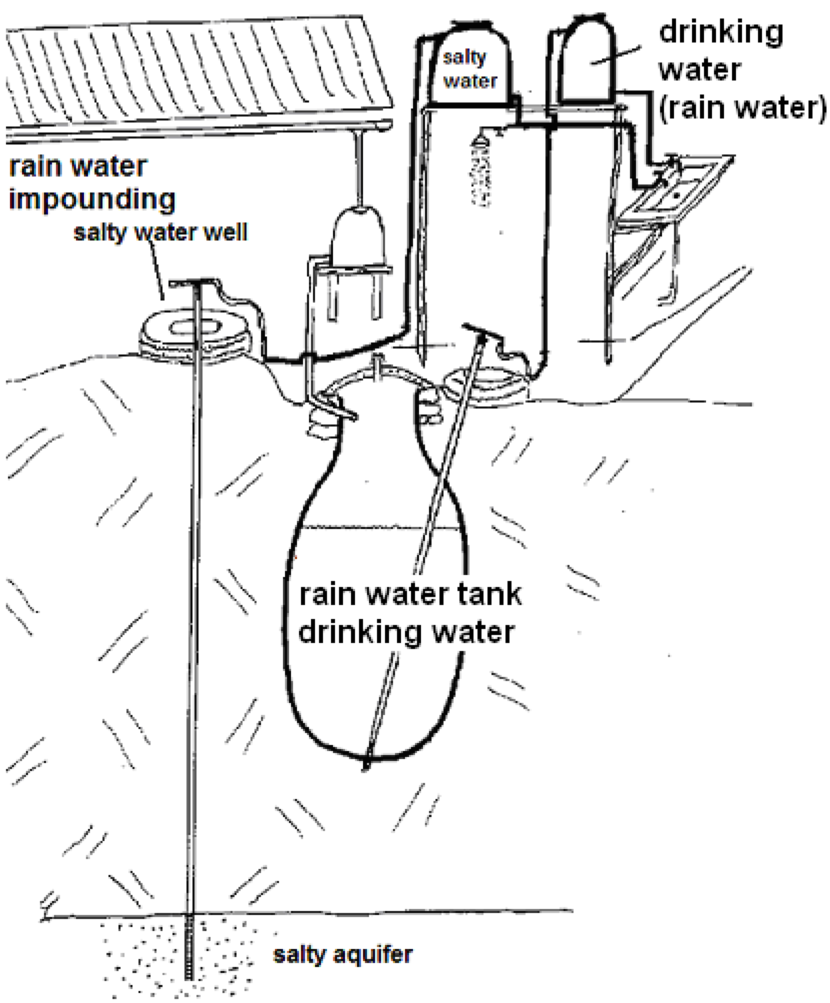


Combined impounding, well drilled containing salty water, and pluvial water impounding

There are places where water at the subsoil is salty, it has an unpleasant flavor, it contains excessive amounts of fluorine or heavy metals, or its bacteriological quality is uncertain.

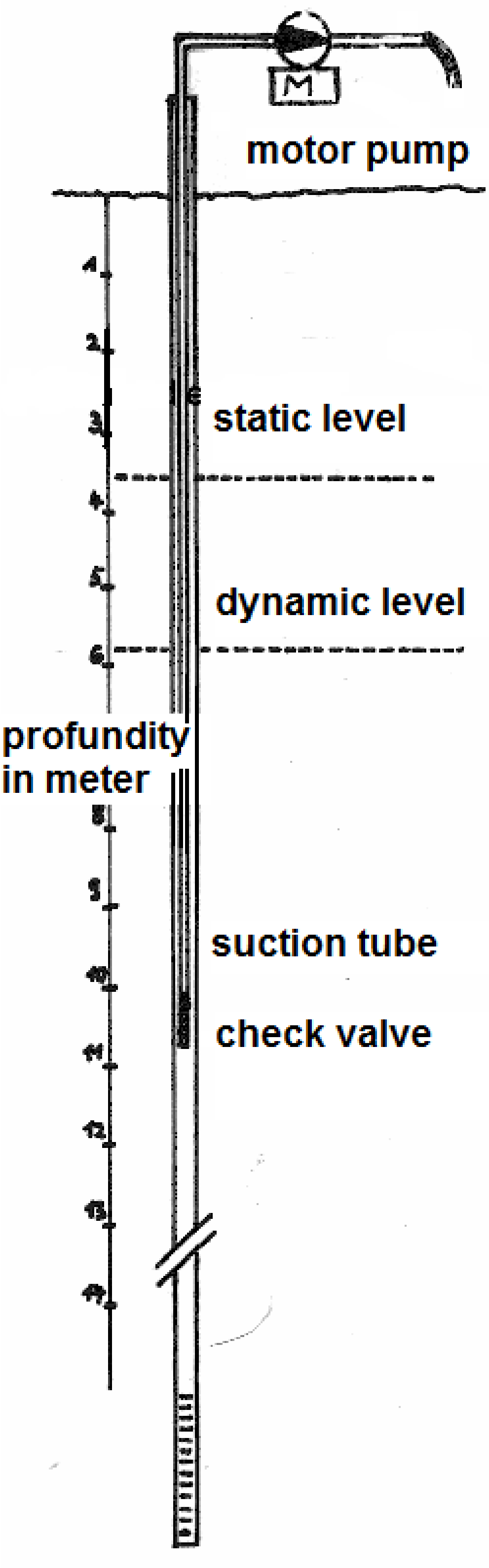
In such cases we offer the combination of a well drilled or excavated, and pluvial impounding. Generally waters from the subsoil can be used for washing, personal cleanliness or for the privy. Fresh rain water is exclusively used for cooking and drinking.

The advantage is that its supply has a minor cost, although service is 100% and practically no limitations exist in water volume. There is no danger for health, originated from having taken too much salt or poisonous substances.



This system has excellent results at the Paraguayan Chaco, where underground water at all depths are salty and not drinkable. Their phreatic level is quite high, about 8 meters. At lower levels, good aquifers exist and an EMAS manual drilling does not surpass 20 meters, which means an approximate cost of 60 US$/Euros. The soil is easy to excavate; it is firm and dry, which allows to set up the cistern. The cistern volume for a family dwelling is calculated in 3000 - 4000 liters, that is to say 3 - 4 cement bags.
As per the characteristic of building it yourself, all the system shown herein amounts to 150 US$/Euros.

Possibilities in the use of motorized pumps for EMAS wells



Single suction
When the static level of underground water is shallow, and the well yields a good volume, then the simplest way to motorize the pumping is arranging a centrifugal pump next to the well.

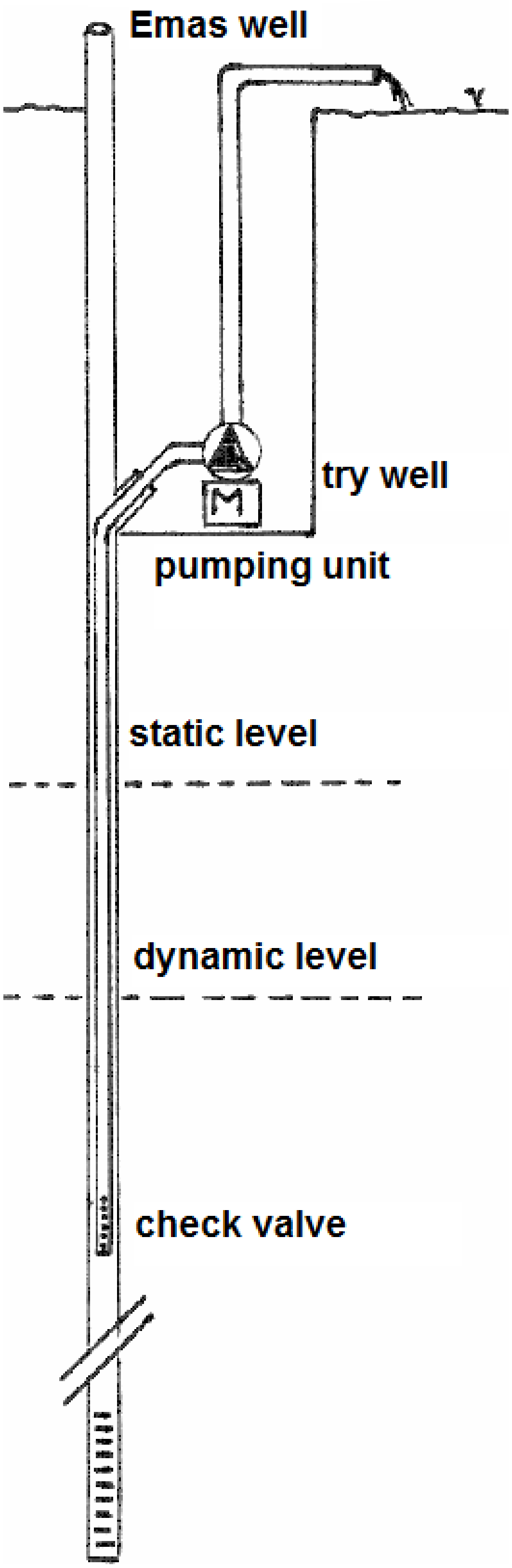
Its suction pipe must be brought down about 11 - 12 meters. Although the static level is located only 5 meters deep, when pumping it goes down to its maximum suction level, that is to say about 8 meters. The suction pipe must have a check valve at its sharp end, to prevent water from flowing back to the well while the pump stops, and thus emptying, given that most centrifugal pumps cannot suction air.

In standard EMAS wells we use 1" or PVC 1" polyethylene flexible pipes for suction with a home made check valve at the bottom, and a good quality check valve located before reaching the pump.

A home made check valve at the well has the advantage that it goes inside the narrow 1 1/4" jacket of the well, and at the same time it can be used as reverse hydraulic ram to pump water upwards and thus fuel the pump.

The purchased check valve (it does not fit inside the well, because of its larger diameter) fully blocks water from flowing back into the well once the system has been set in operation.

Use of a motorized pump in an EMAS well with a deeper static level (pump brought down in a dry well).



In this case the static level is so deep that it does not allow suction from the surface. The problem may be solved bringing down the pumping equipment to such a depth that the suction is possible.

Usually, next to the EMAS well, a dry well is excavated, with a diameter of 1 meter or more. The depth of the dry well determines the static level during the low water season, and its highest level during the rainy season. Normally the static level does not raise more than 2 meters in deep wells, and the pumping equipment can be set up about two meters above the highest level. But if during the rainy season the static level in an EMAS well goes up more than 5 meters, this system is not applicable any more, because the risk exists that during the rainy season the dry well will be overflowed, and during the low water season the static level goes down to such a point that the pump will not be able to suction water.

The walls of the dry well can be stabilized with a cement layer.

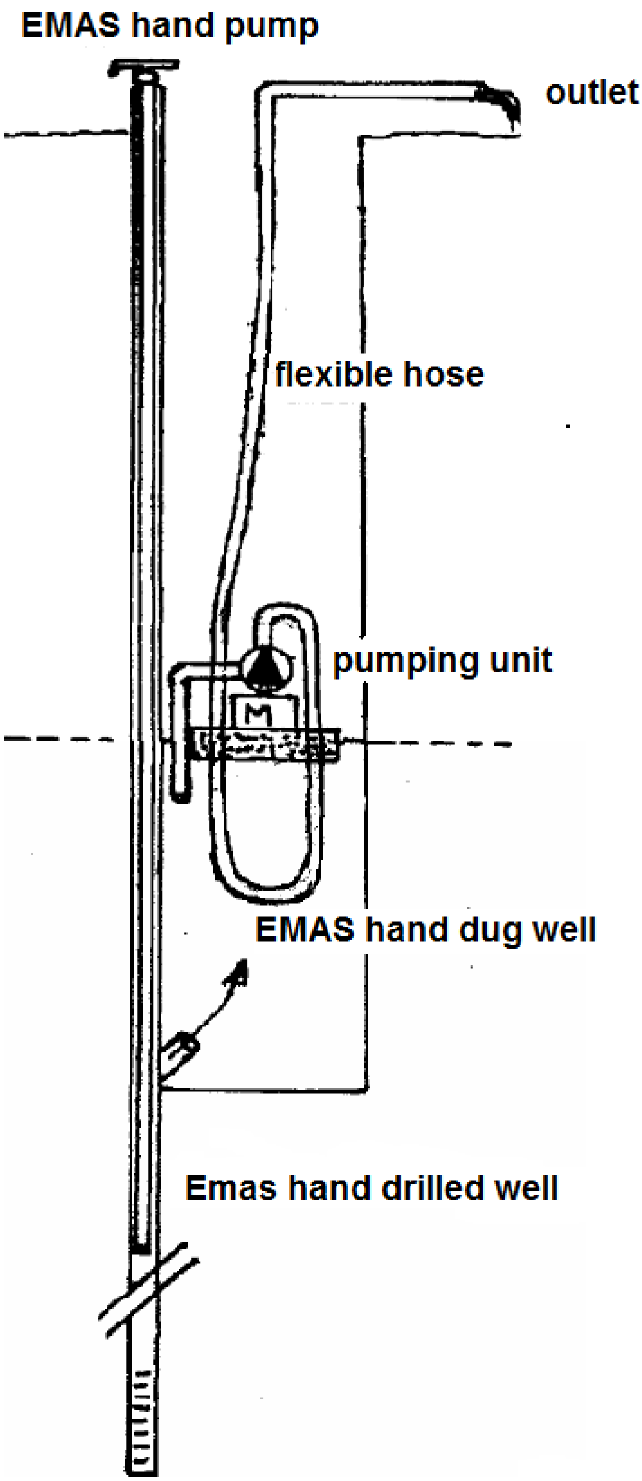
Besides, you must prevent rain water from getting into the dry well and damaging the engine.

It is advisable to use an electric engine, but also a gasoline operated motor can be set up, always being careful to draw out the exhaust pipe up to the top.

In case the motorized pumping equipment fails, a FLEXI pump can be easily set up.

Motorized pump in a well excavated and deepened with the EMAS system

When the EMAS drilling does not provide the sufficient water volume, drilling can be combined with an excavation (Please see well drilled with reservoir).



The case may be similar when an excavated well does not provide the sufficient water volume. In this case the excavated well can be deepened by means of the EMAS drilling until reaching a better aquifer.

If the suction from the surface is not sufficient, then this alternative is offered.

The pumping equipment is set up on a pontoon, which may be built of plastic containers or of Stiropor. As an engine, only an electric engine is adequate, since no good access exists. The pontoon goes up and down with the pump inside the well. The flexible hose compensates the ups and downs. This system is more useful in wells wherein the water level highly varies during the low water and rainy seasons. A check valve must be arranged at the suction pipe, to prevent water from flowing back into the well.

The same pumping system is also applicable in single excavated wells (with no EMAS drilling).

It is advisable to set up a "float" switch that automatically switches off the pump engine when the well is about to be empty. This will prevent damages in the pump.

Some advantages of this combined well are its higher volume, its large deposit, and a more effective pumping.

In case the motorized pump fails, a EMAS pump can be easily set up.

Pumping with compressed air

Air pumping is one of the simplest forms that exist. You only need a small compressor with its engine, whether electric or gasoline operated, and a thin pipe or hose that must reach the bottom of the well. The advantage is that all the revolving and abrasion parts are located on top, they are easy to repair and to maintain. The air pump can extract water from a well with a static level below 20 meters, provided the recovery be good and if the well has the appropriate depth. The relation between energy consumption and water volume is acceptable when dealing with wells of a reduced diameter.

In the compressed air pump, advantage is taken from two elements of a different density. Air forms with water a sort of a foam which is much lighter than water, and it can float. Thus, on the water a foam column is formed, which may even reach the top of the well. Three factors have influence on air pumping:

First : The relation between the dynamic level and the well depth. (The dynamic level is the one reached by the water level under constant pumping with a determined volume).

It is convenient for this relation to be at least one per one, that is to say, one part of water and one part of air. For instance : a 40 meters well has a static level at 10 meters. Constantly pumping 1 liter per second the level goes down to 20 meters (dynamic level).

Then the relation in the well is one per one, this means one part of water and one part of air. The extraction volume is poor, because much air is required to produce such a light foam that it can reach the top. Also, the yield is low.

If the well has 60 meter depth, that is to say 40 meters of water, then the foam needs less air to go up and the mixture water - air contains more water; therefore, we get a higher extraction. Deeper the part of the water in the well drilled, more water will the air - water mixture contain.

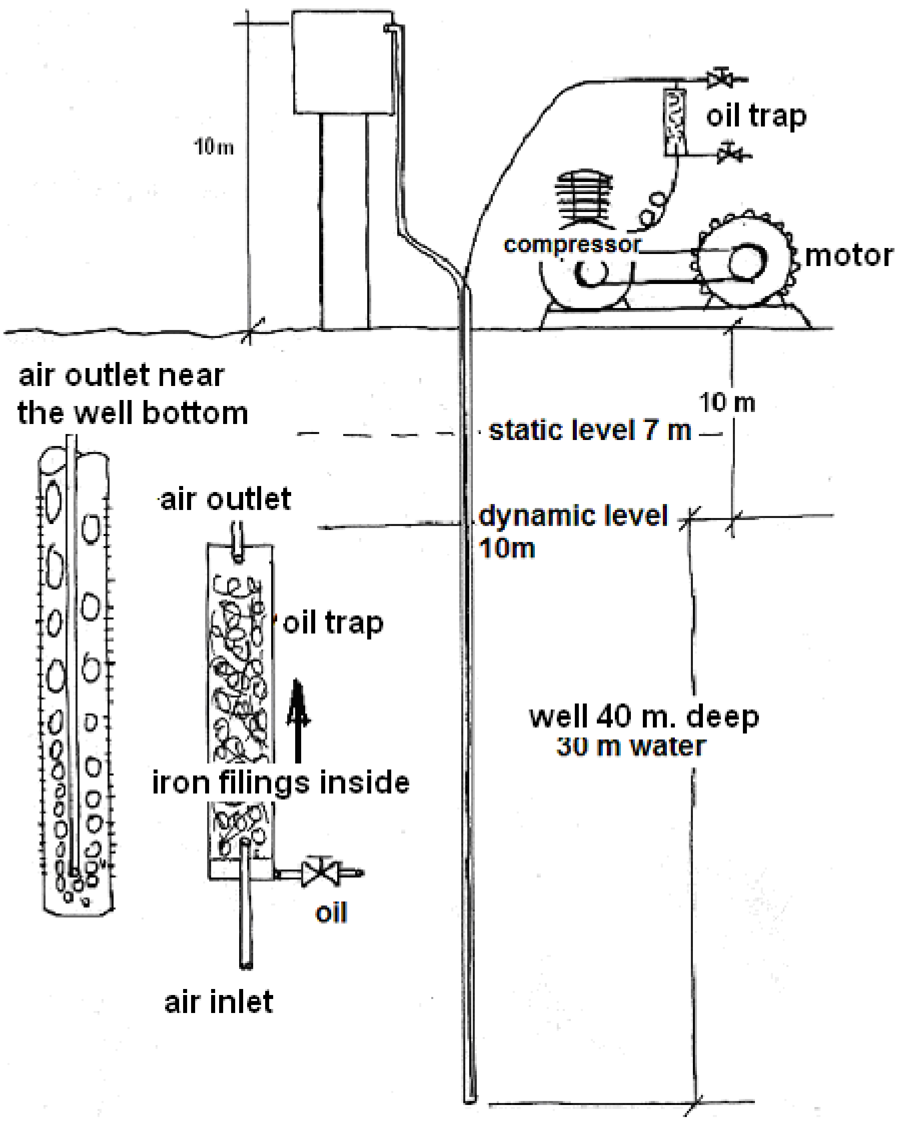
Second : The volume of air injected. If air is scarce, then the mixture does not float until overflowing. Too much air means a squander of energy, without significantly increasing the volume.

Third : The diameter of the well or the diameter of the extraction pipe also determines how much air is needed. Wider it is, more air will be necessary. Since usually money is only available for a small engine and compressor, a narrow extraction pipe is advantageous (1 1/4" - 1 1/2" outlet pipe, air pipe, 1/2" polyethylene hose, 1 HP compressor, 1,5 - 3 HP engine).

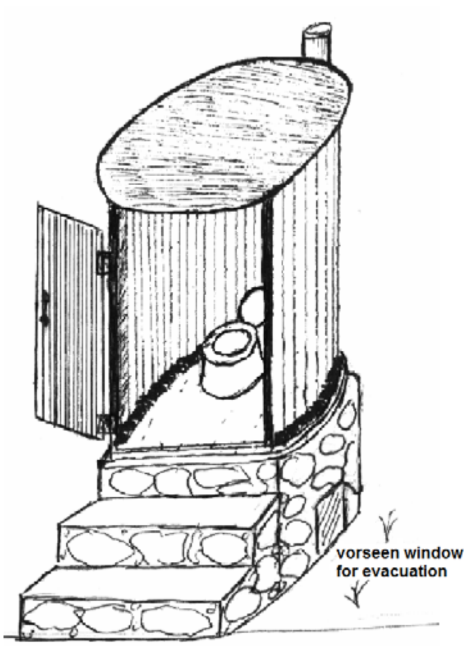
More than 50% of EMAS wells are adequate for compressed air pumping.

They have a good recovery, with about 11/s by their synthetic pipe, and they have a favorable air and water relation, as a result of their significant depth. Because of their reduced diameter, of only 1 1/4" - 1 1/2" they do not require a very powerful compressor or another extraction pipe.

Their installation is quite simple : The engine can be electric or gasoline operated. Drillers use a gasoline operated engine with only 3 HP and operated with a minimum acceleration. The compressor is the smallest one used by tire workmen. An air chamber is not needed; air is ejected directly from the compressor, it passes by a few cooling turns and goes into the oil disposal. Therefrom, a 1/2" pipe reaches the bottom of the well. Air is ejected therefrom, by its open side. Water gets into the tank, like 'coughing' water with air. The oil disposal or oil trap is a piece of 1 1/2" galvanized iron pipe and full of wood shavings, like the ones used to scrape the floor. The fine smoke originated by the oil exhausted from the compressor sticks to these wood shavings. The base of the valve serves to pour out the accumulated oil. By means of the upper valve you can remove the air pressure from the pipe, and thus obtain a smooth engine start.



The EMAS latrine does not affect aquifers, it is comfortable, hygienic and almost odorless.



If we wish every dwelling to have its own water resource impounded, using underground waters, we must prevent them from being polluted by infiltration of sewage waters.

A latrine is accepted when it is easy to set up, when it is inexpensive, it has a nice appearance and most of all, when it does not have a bad smell. The EMAS latrine has more advantages than a water closet with hydraulic entrainment because it is odorless, it is very economic because water is not spilled, it does not damage the aquifer, and its content becomes a good manure.

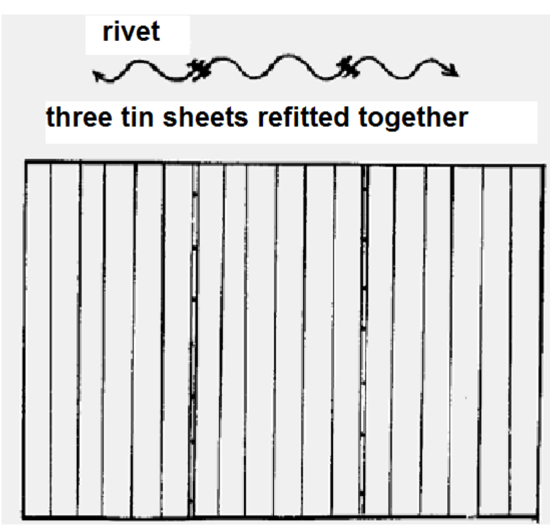
These latrines are offered in two kinds : the High Set Up Latrine and the Portable Latrine.

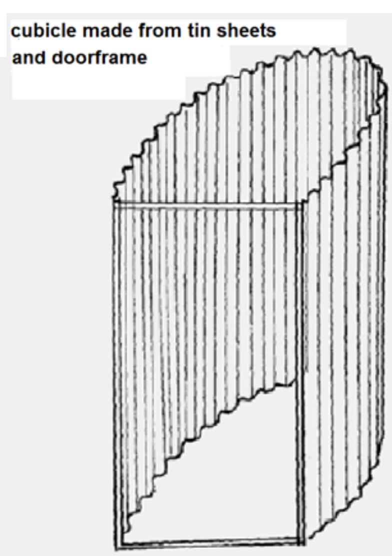
As you can observe from the design, this is a booth built with metallic plate and with a ferro cement tile as platform, and another one as a roof. The door is made of wooden frames or 15 mm x 15 mm industrial pipe and lined with corrugated tin plate. A chimney painted in black extracts air.

Following we explain, step by step, how to build the EMAS latrine.

The booth . You can build it semi round, round or oval shaped. It needs no woodwork, since the corrugated tin plate or the trapezoidal plate is self supporting. The laths for the door and its frame are not difficult to find. If many booths must be transported, there is no problem because the material is not bulky and it has not much weight.

1st step : material for the walls : You need 4 corrugated tin plate sheets Nº 33, or even better Nº 28, or three trapezoidal plate sheets, from 1,80 to 2 meters length, 12 meter wooden laths or 15 mm x 15 mm profile pipe, aluminum rivets, 2 hinges, 2 knobs and 2 latch keys.

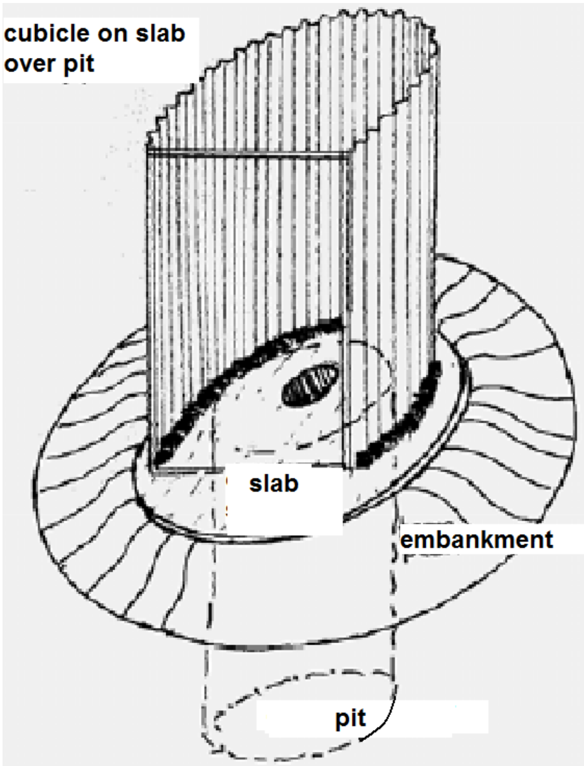




2nd step : the wall and the door : The door with the laths is set up on site.

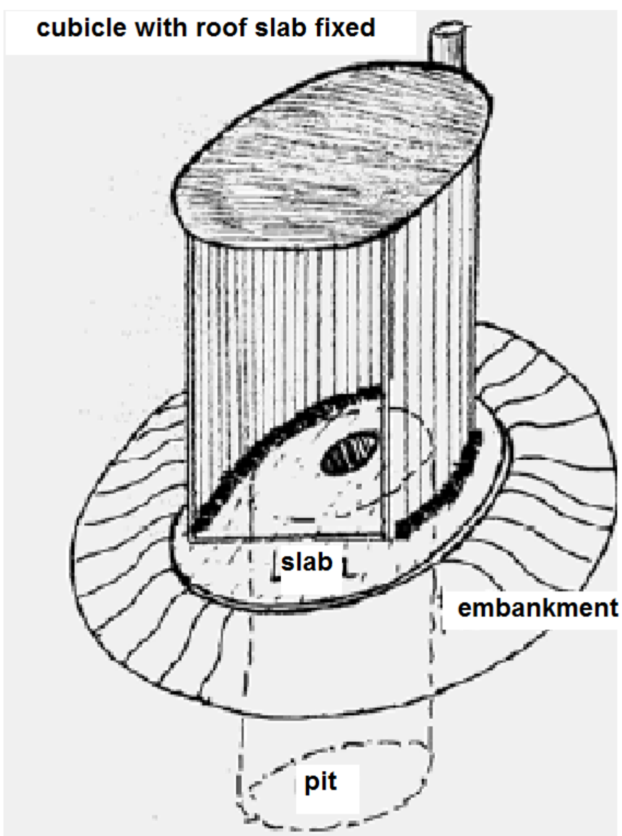
The 4 corrugated tin plates are joined with rivets as per their width, to obtain a plate of at least 2,40 meters wide. Then you nail both sides to the door frame, giving it a semi round shape at its bottom.

3rd step : the floor and the roof : A ferro cement tile is cast which serves as the base, with a hole left for the seat. It is better to build it of ferro cement, because it is lighter and more economic. The measures of the base are taken according to the shape of the booth. The thickness at the bottom should be of about 4,5 cm; at its four "corners" it has 4 rings or hooks. The roof tile is about 4 cm thick. As iron bars, also 1/8" are used.



4th step : the choked up well : EMAS does not recommend the hole to be too deep, since it can affect the aquifer, be easily filled with water, or it may collapse and set in danger the booth with the person inside it. 60 cm - 80 cm diameter and from 1 meter to 1,20 meters depth will suffice for one family. A hole for a dry latrine, having more than 2 meters depth has no advantage; on the contrary, it has the already mentioned risks.

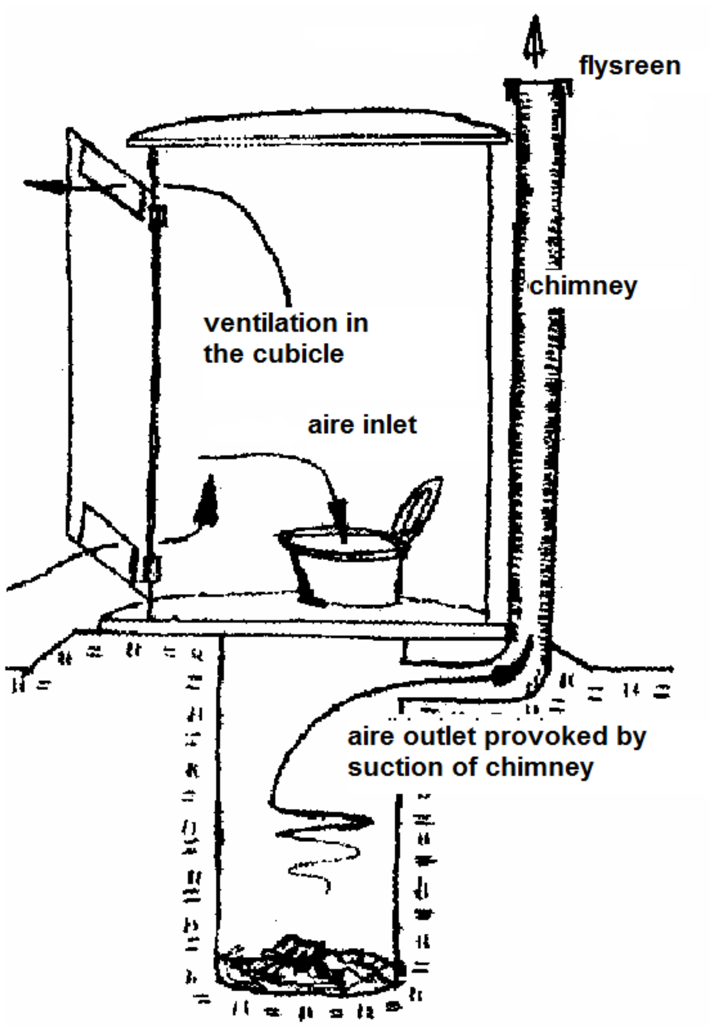
5th step : setting up the booth 'in situ' : After having excavated the hole, using the earth left over for an embankment, arrange the tile for the hole, being careful to keep it at the same level. Then set the plate booth on the tile and give it the oval shape.



To fasten the plate on the tile, put a mortar on both sides around the plate.

6th step : the roof : Like the floor tile, a thin ferro cement tile is set up for the roof. We advise the tile to be thin, but reinforced with 1/4 iron bars. Like the floor, its edge has a hard mortar lining between the tile and the corrugated tin plate.

7th step : Ventilation system : This privy has two kinds of ventilation. One of them is for the environment inside the booth, wherein air circulates through the windows at the door, and the other one is for the septic well.



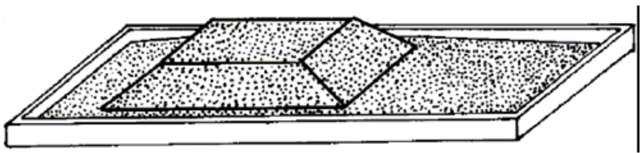
The ventilation of the well eliminates odors in the booth, because there is air intake by the seat and air outlet by the chimney. Because of this movement, no bad odors emanate from the cavity. For air to circulate by the chimney, there must be a difference in the atmospheric conditions. During daytime, solar rays warm up the chimney (They also warm it up when the sky is cloudy) and during the night, when the air is fresh outside, it is lukewarm in the well, and it tends to go upward. The chimney must be painted in black, to absorb solar rays. The revolving pipe, always looking opposite to the sun because of its tail end, provokes an additional suction in the chimney, and increases air extraction.

Budget for an EMAS latrine

2 cement bags
1/4 m3 sand
4 corrugated tin plates Nº 28 - 28
2 laths or 15 mm x 15 mm profile pipes
hinges, knobs, latch key, rivet
One 1/4" I iron bar, 6m
1 Kg of wire
1 PVC 4" bend
1 revolving bend
paint
1 toilet seat
transport for purchase of material
use of tools and welding
2 daily wages, including setting up on site

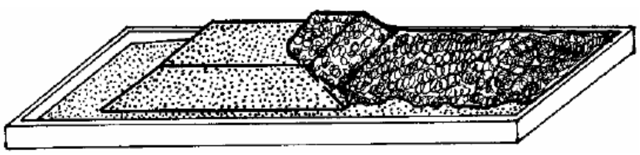
How to build a laundry tile

In rural areas it is frequently difficult and expensive to obtain a laundry tile. High transport cost, the risk of its being broken, and the high price itself make people give up having this useful domestic tool.



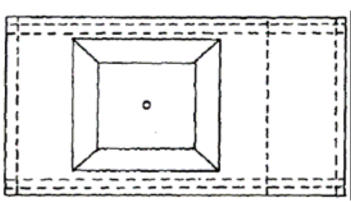
The person who knows how to build his tile on site has all the advantages, since the most important part of the material, which is sand, is frequently found in rural areas. Finding half a cement bag and some iron bars is not so difficult.

Its construction :
A fine sand mold is cast, or simply an earthen mold inversely as the tile will be shaped.



To mold the earth/sand, moisten it a little. If the sand is somewhat thick and cannot be easily mixed, then mix it with sifted earth and form moistened mud. When molding, we recommend people to be careful and see that water always falls at the bottom, where the drainage is located. For this purpose, it must have an inclination from its lateral areas towards the middle part. The same thing is applicable to the bottom of the tile: the drainage hole must be at its lowest part, and since the mold is inversely set, it should be on its upper part.

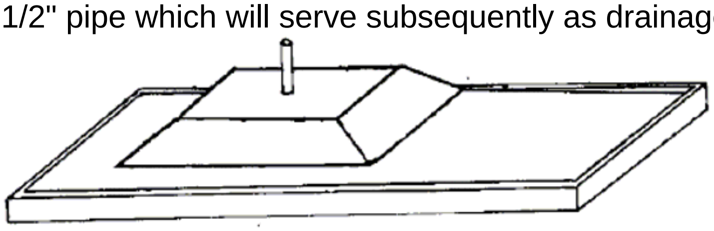
The mold must be polished as much as possible.



Then prepare a solid cement mortar, 3 : 1, and spread it from the edges to the inside part. This first layer must end at its upper part. The thickness of this first layer shall be about 2,5 cm.

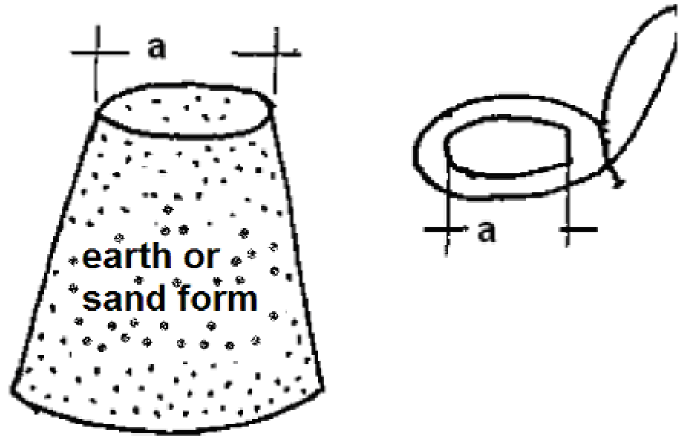
Use a 1/4" or 6 mm iron bar. Please see iron bars' schedule.

On it, another cement layer is spread, of about 2,5 cm. At its upper part, insert a 1 - 1 1/2" pipe which will serve subsequently as drainage.

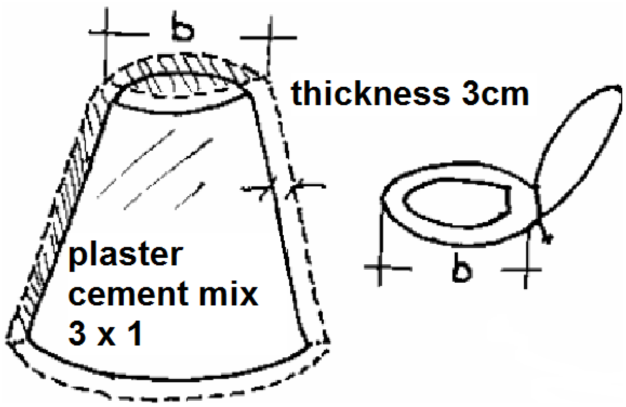


When 2 days have elapsed, you can carefully make the tile stand. So as not to break it, hold it at one of its narrow sides when picking it up. Scrape the sand, then wash it with a brush or paint brush, and then finally polish inside with sifted sand and cement. To polish, use a piece of sponge as a tool. For the cement to continue being moistened while it hardens, arrange wet sawdust on it.

How to build a seat for a latrine



The EMAS latrine has been described in the module referred to water hygiene. Here we describe how to build the seat for this latrine. For a latrine to be accepted, it is most important that its seat be comfortable and hygienic. A plastic cover and a plastic seat wheel are indispensable for hygiene and comfort, therefore they should not be overlooked.

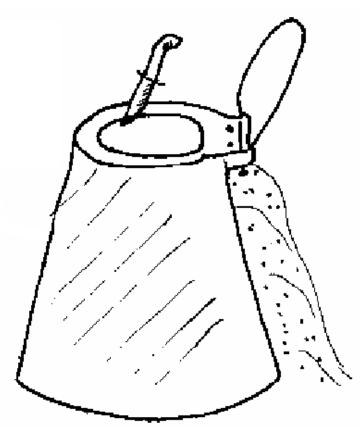


Building a seat for a latrine is quite similar to building a laundry tile. A mold is made of earth/sand, then it is made resistant with cement mortar. At its upper part, the earth/sand mold must have the same diameter as the seat inside it. It is easier to spread a layer with mortar on all the mold, including its upper part.

To arrange the seat, you can perforate the edge of the seat itself (a simpler manner) or make the holes at the projected points where the seat wheel rings are arranged. With pieces of wood or earth, a support is arranged, and cement is applied on it.

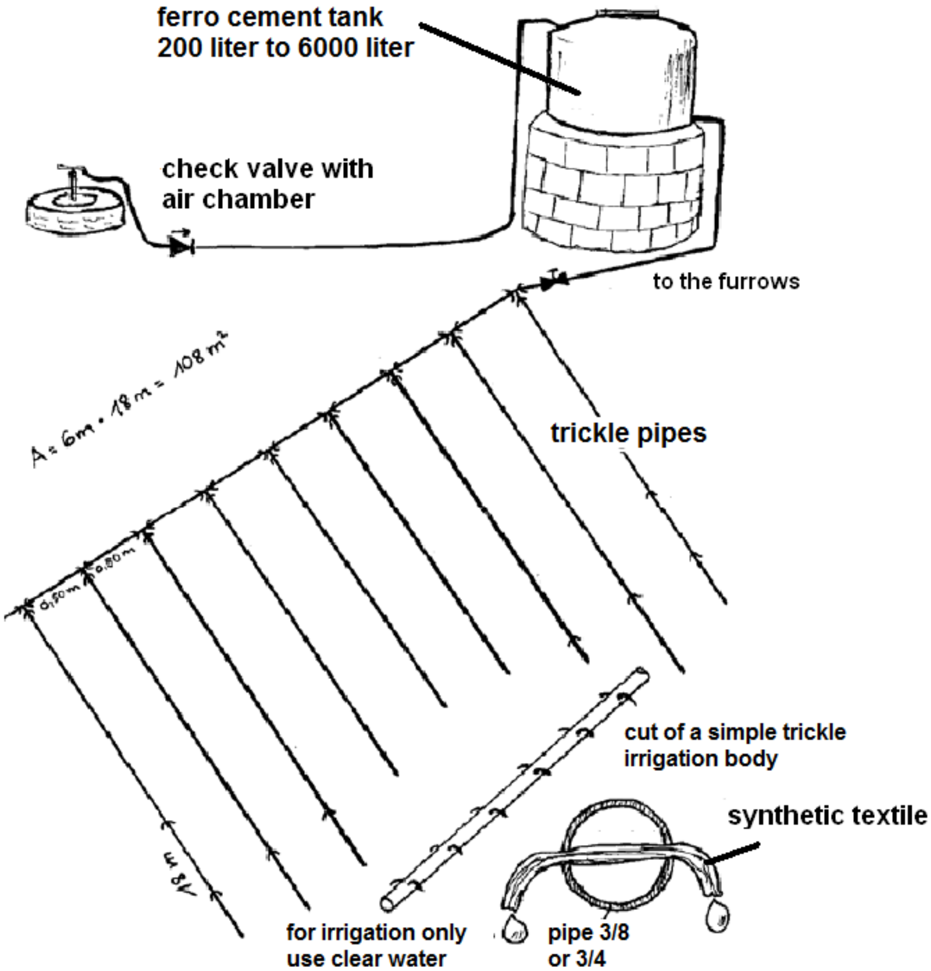
Finally cut the intake hole according to the measure of the seat wheel. We recommend the diameter of the seat to be slightly larger than the seat wheel, most of all at its front part. The seat does not require iron reinforcement, because the form it has gives enough stability to it. After 12 hours have elapsed, the final coating is laid at its external part, and 48 hours later sand can be scraped and the seat is finished.

cuting the shape of the seat



EMAS micro irrigation system

The EMAS system allows several kinds of irrigation. The most common one is by gravity in the furrow itself. First fill the tank, whether it is a 'pitcher', several big ferro cement containers, and through piping, water is conveyed to the furrows.



The great advantage of dropping irrigation is that water is used in a much higher volume, since there is very scarce evaporation from the earth, and almost no losses exist due to infiltration to deep areas.

Therefore, with the same water volume, even four times more plants can be irrigated.

For years EMAS has developed a very interesting dropping micro irrigation system, which is ideal for a family vegetable garden, or to cultivate small coffee plantations.

Many components of this system are already known, and have been analyzed in this text, such as the EMAS FLEXI pump, the ferro cement tank and the filters. It is not complicated to distribute water to furrows through piping, since we know how to set up accessories such as T's, bends and plugs.

In a dropping irrigation all dropping bodies must equally drop. Dripping bodies must not be easily obstructed but in case they do, their repair should be easy.

Generally these criteria are complied by commercial dripping bodies because in their inner part they contain a sort of labyrinth where pressure is exerted to such a point that only drops are ejected. In those systems called "home made", holding screws are used to regulate dropping, but they tend to disarrange themselves with no apparent reason;

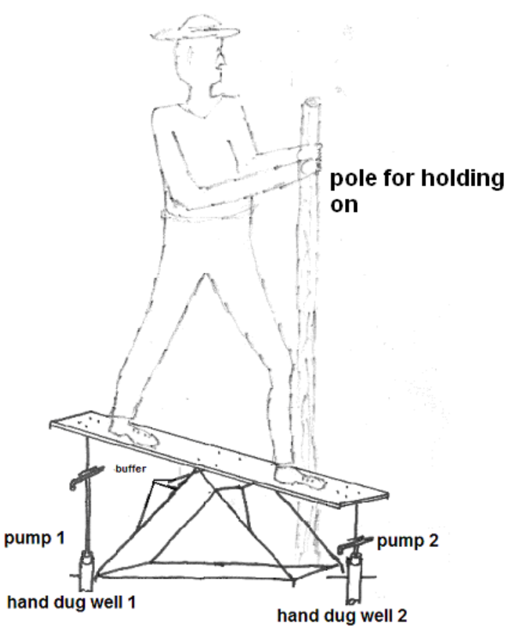
they are generally blocked, whether by very small dirt or because rust is formed at their sharp end.

EMAS had the idea of transversally perforating a pipe and string together, through the hole, a piece of strip made of polyester synthetic cloth or perlon (also old nylon stockings would do). This strip is tightly tied to the pipe. Water is forced to get into the space where fibers are, and pass through these capillary by the perforated hole and then it drops outwards. When water drags small dirt, dirt remains attached to the strip inside the pipe like in a filter. Dripping is reduced only when all the strip inside the pipe is blocked with dirt. To reactivate dropping and clean the strips, the strips are moved pulling them on one side and then on the opposite side several times, until no more dirt is left. So as not to clean the dripping bodies every time, only water with no particles must be used for a dropping irrigation. If crystalline water from a well is used, there will be no problem. But if you are using water from a river or from a lagoon, then a filter must be arranged. Please see EMAS filter.

Dripping bodies are arranged according to the farming made. When sowing vegetables, a dripping body every 50 cm will suffice, that is to say, from 2 to 4 dripping bodies for one square meter. Usually in a dropping irrigation, only some small stains remain wet on the surface, and not all the sown land. Capillary attraction makes humidity be distributed in the subsoil. To reduce even more water evaporation at the ground surface, the earth must be scraped on top, like when removing weeds, and let the earth loose to "balance" and thus interrupt capillary channels which transport humidity to the surface.

Agricultural industrial undertakings take advantage of dropping irrigation when applying chemical fertilizers to plants. In our case, some chemical fertilizer is dissolved, then turbidity must sediment, and this scented water is applied to the ferro cement tank. Therefrom, the fertilizer reaches the plants together with water.

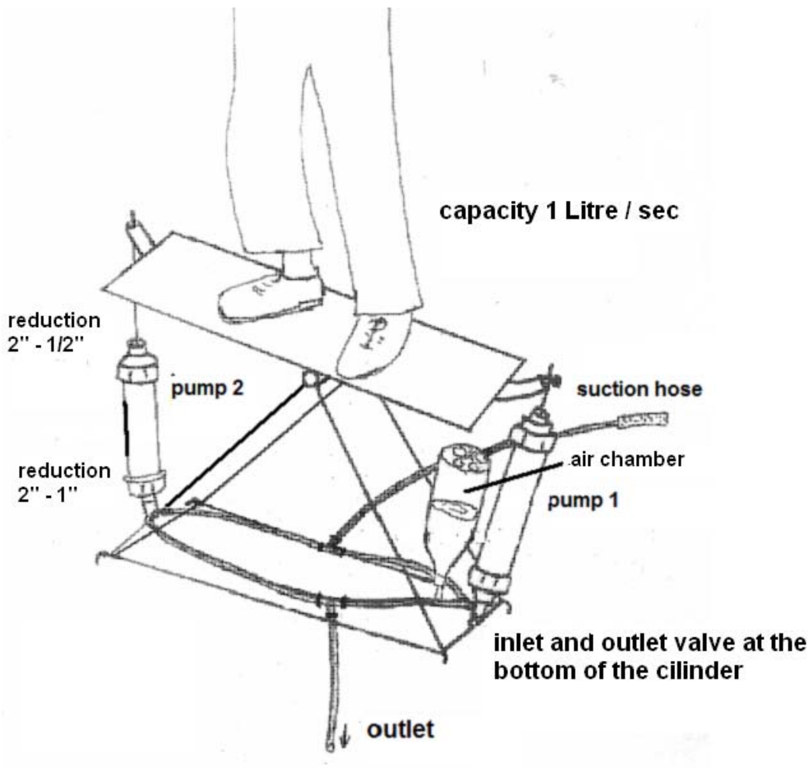
Pedal adapted EMAS pumps for irrigation



There are different types of pedal operated pumps, most of all for their use in irrigation. Pedal work has the advantage of being less tiring than the manual form, since the muscular structure of the legs is stronger than the one of the arms.

Pedal pumping is similar to a children's seesaw. Differing from other patterns, EMAS pumps have the advantage of conveying water from a fairly good distance, or to elevate it to a height up to 40 meters.

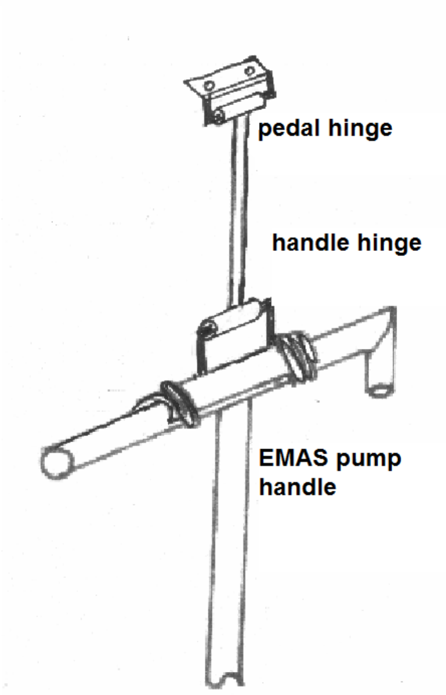
Pumps can be built for flow or height, merely varying the diameter of the cylinder. The EMAS pedal system always has two twin pumps operated by a lever with equal arms. When one side goes up, the other side goes down. When going up, the cylinder is filled with water and at the same time the other cylinder is emptied, because its piston goes down. Presently there are three different constructive types.

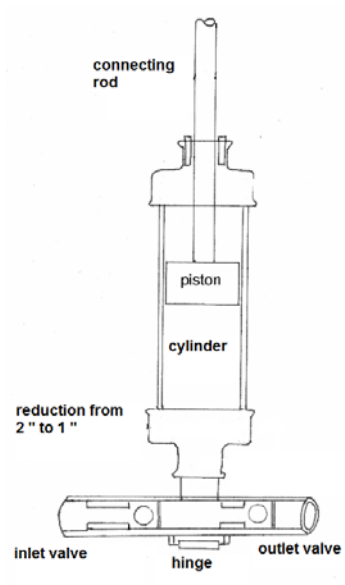


1 . lake or river pumping

For this pumping, a compact and portable mechanism is used.

The valves are made of galvanized pipes and their accessories, very similar to the ones of the mud pump for drilling wells. Both valves are located at the same level, at the lower part of the pump, and they form the valve head. On its upper part it has a 1 inch screw thread, to which the reduction coupling is threaded for the plastic cylinder pipe. The advantage of a PVC cylinder is that it is more polished, and therefore it has much less friction than a steel pipe. The diameter of the cylinder may vary, according to the pressure needed. Usually diameters from 1,5 to 2 inches are used for irrigation. The cylinder is a pipe of about 40 cm length, with a screw thread on both sides. A reduction coupling connects it with the head. On its upper part it has another reduction coupling which operates as a guide for the connecting rod. The piston is simply a piece of galvanized pipe, plugged on its lower side. If it has been given a precise measure, it needs no gasket, or else it can carry a gasket made of tire or cloth. The connecting rod has two hinges that allow to compensate the motion, fastened on the pedal board. All the framework is welded and made of 1/2 inch iron for construction.





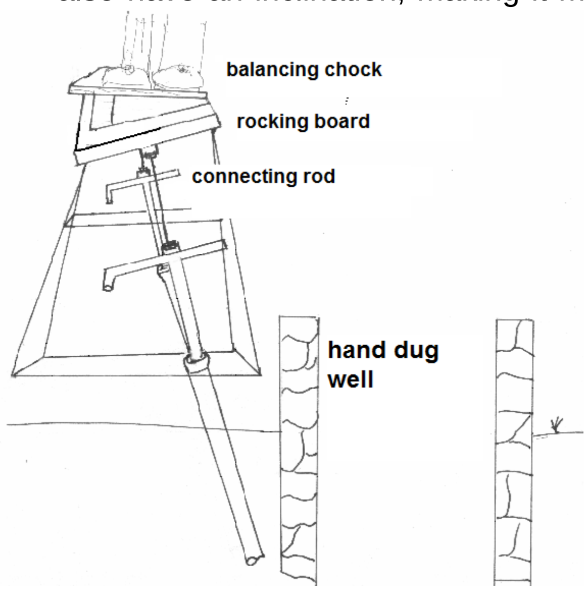
2 .   pumping by twin wells drilled

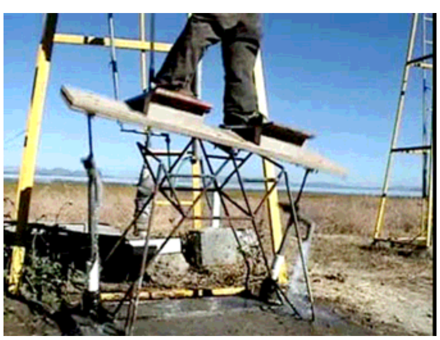
If the subsoil has good quality aquifers and if the land can be drilled, you can choose the twin wells' system. With the EMAS system, first you drill two wells, 80 cm distant. Then set up EMAS pumps therein. In case of using 2" jackets, flow pumps can be used, but if water is found at more than 10 meters depth, or if the recharge is not eminently good, it is advisable to use 1" standard pumps.

The remaining part of the mechanism is quite simple. The seesaw installed, at both ends you put the connecting rod with its two hinges. The fastening between the connecting rod and the holder is made welding a 3/4" pipe which has been cut lengthwise and operates as a gearing, to which the holder is tied with a pneumatic tire strip (see the figure).

3 .   pumping of an excavated well

The system is quite similar to the pumping of a twin well. Laterally you set up two pumps, 80 cm distant. Given the inclination of the lateral pumps, the shaft of the "seesaw" must have the same angle. However, this means that the balance board will also have an inclination, making it most uneasy to step on it. Therefore, to level up the stepping spot, place two platforms to operate as wedges on the board.



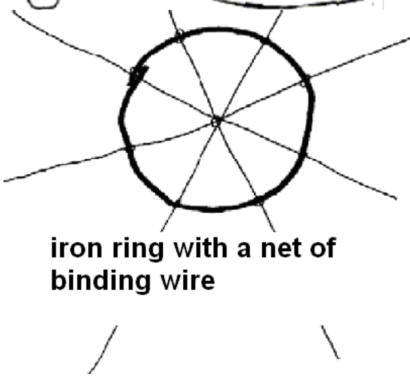


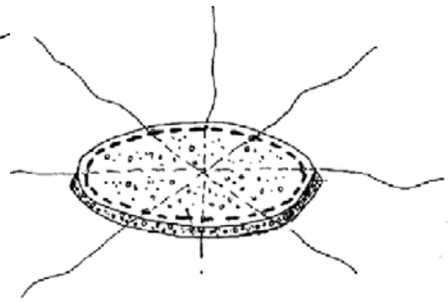
Small ferro cement tank or 'pitcher'

This type of container is very economic, it has a long life span and it can be built almost at every place and of all sizes. In Bolivia, the price of a self construction tank, with a 200 liters volume, is of about 10 Euros/US$.

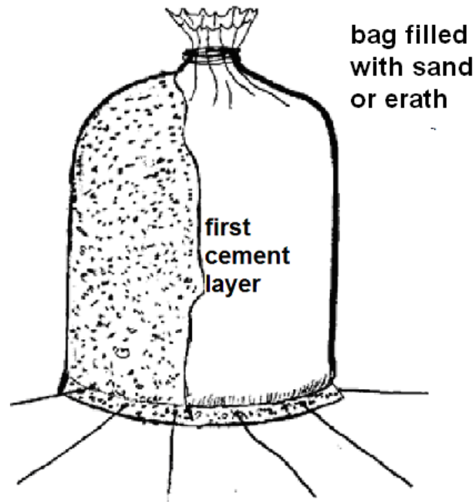
These are the steps for its construction :
Set up a screen wire on an iron ring. Prominent wires will serve subsequently for to reinforce the wall.

Spread a firm cement mortar on the screen.

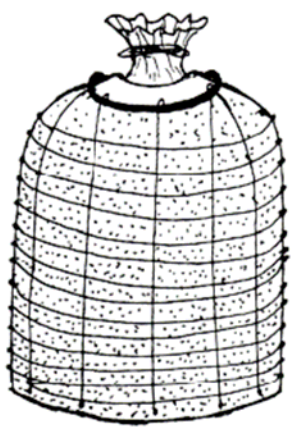




Spread a firm cement mortar on the screen



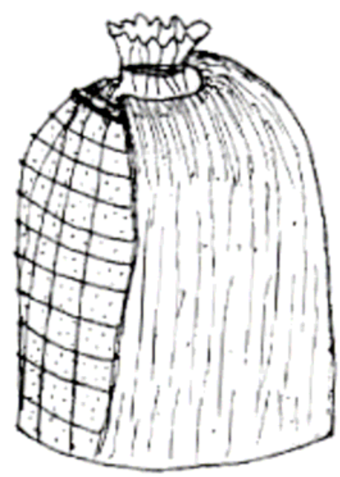
When the cement at the bottom is half dried, arrange on it a bag that should have the same size as the future tank. Fill this bag with earth, sand or sawdust.



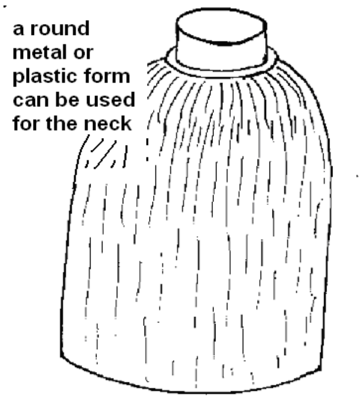
Then spread the first coat of the mortar on the bag, 1 :3.

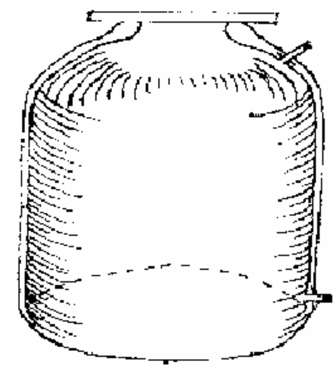
Raise the lateral wires, hooking them to a small ring which will reinforce the mouth of the tank, and is horizontally enveloped with lashing wire. Set a second mortar layer on the wires.

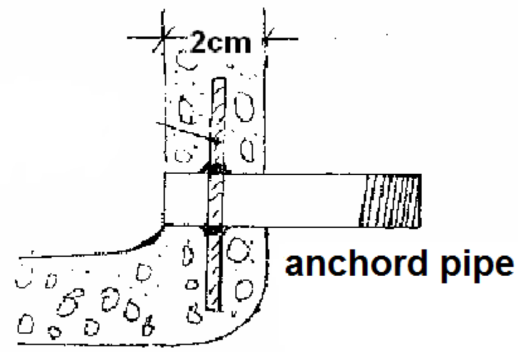
When the neck is finished, arrange the connecting nipples.



When about 20 hours have elapsed, the bag is emptied and the tank is finished. After a cement whitewash layer inside and out, the tank must be kept moistened for about 5 days, thus the cement will harden.







Some uses :
As triple septic chamber;
As domicile water reservoir ;
In the EMAS sanitary module;
As underground tank in a micro impounding.

Building PVC accessories

1 . Hard soldering with special adhesive.

We use this kind of soldering to join the pipe bells. The adhesive consists of a diluting liquid with diluted PVC material.

When spreading it, the diluting liquid also blasts the pipe, it dilutes part of its surface and both materials are mixed, the one from the pipe and the one from the diluting liquid. When the diluting liquid evaporates, the PVC from the pipe and the liquid have fully mixed. It is most important, when soldering, to have the pipe surface appropriately clean, so that the diluting liquid may blast the pipe and thus form a joint.

2 . Hot air soldering

This system is very practical and it has multiple uses. It operates like a hair dryer. Hot air softens the material of the pipe, and soldering solution is added with a small soldering bar made of the same material as the pipe. When it is pasty, the pipe PVC is tightly joined to the soldering bar.

3 . Plate soldering

It is used by EMAS; this can be used almost everywhere and practically with no special tools. We can solder accessories resistant to pressure and drainage accessories of all measures, whether bends, T's, Y's, siphons, or any accessory we wish to have.

These are the steps:

For practice we shall build a 1/2" bend

As a first step, we cut two pieces of about 4 cm length from the pipe bar. They must not be cut straight, but in a 45º angle (Chart 1). To obtain the exact angle, we can use a square.

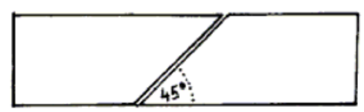


fig.1

After having cut the pipes, the cutting has to be polished and you should evidence the angle with the square.

Generally both pieces are polished until they can form a 90º bend (please see Chart 4). Then, with a knife, clean the shavings attached to both sharp ends.

You need a flat plate for soldering. A piece of string, a thick plate, the flat bottom of a frying pan, or else the base of an old electric iron will do.

This plate is arranged on a point of hot supply.

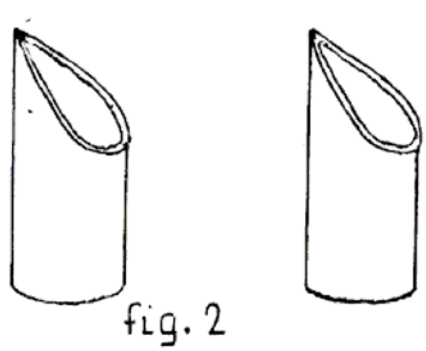


fig. 2

Before soldering, the appropriate temperature must be evidenced, using another piece of pipe and slowly scratching on the hot plate. If the plastic holds, like a chalk stripe, it is hot enough. If the white off color of the PVC quickly turns yellow and then black, it is too hot. The temperature is adequate when the color slowly turns yellow (within about 15 seconds) and there is no smoke.

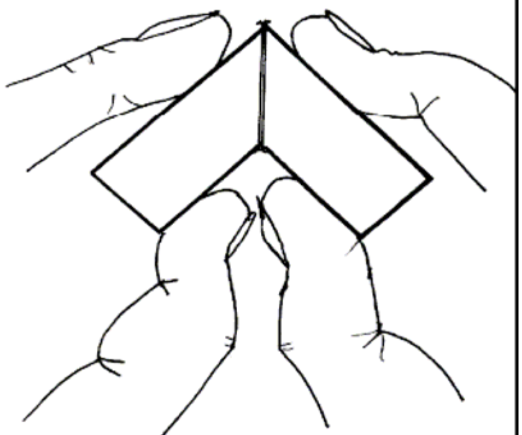


fig. 4

When the temperature has reached the adequate point, press the two pieces on the plate (Fig 3) and move them slowly to be sure that both surfaces are being equally softened. Before picking up the pieces from the plate, stop pressing for about 3 seconds, so that a pasty material may be formed, which will subsequently serve for soldering. Then pick them up quickly and join them with no delay (Fig 4).

Frequently you may be nervous at this moment. As a help to find quickly the proper position, use the position of the index fingers (Please see the Fig.)

Practically the bend is finished. If you need a bend with bells, you must introduce a pipe of the same diameter to the overheated sharp end. Then the stretched part is quickly cooled down with water (See Figs 5 + 6).

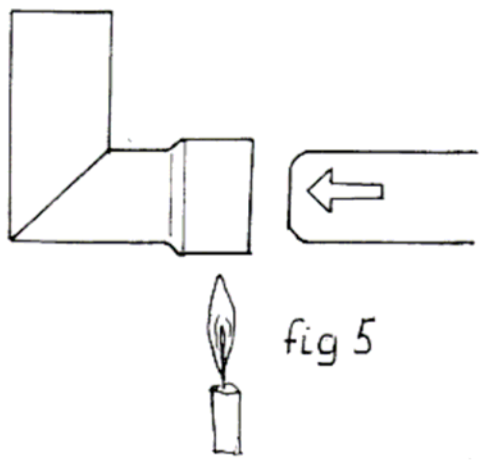


fig 5

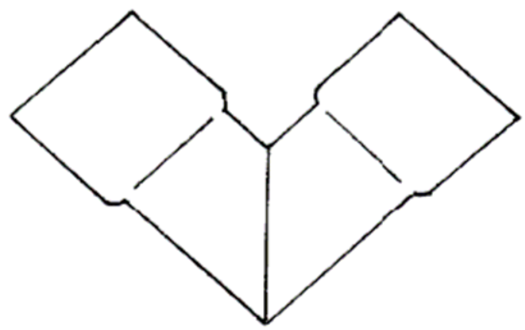


fig 6

<u>For a practice we shall build a 1/2" pressure resistant T</u>

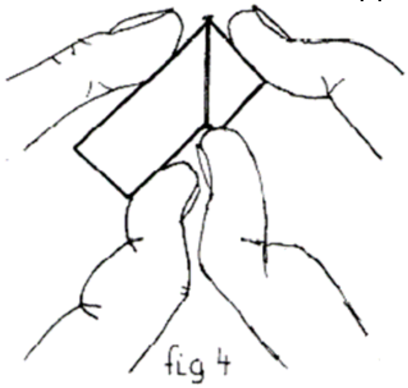
The T consists of two halves of a bend.

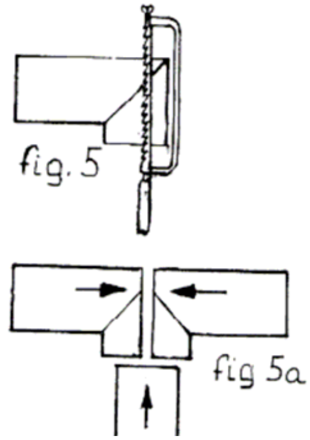
First build two bends as already described. The difference is that one arm of each bend is short (approximately 5 mm) and the other arm is normal sized (Please see Figs 1,3, 3).

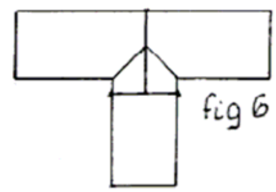
Like the bend mentioned before, solder to obtain two bends.

The next step is to cut each bend at slightly less than its half (Fig 5) and join the tow bends once more, thus obtaining a T (Fig 5ª). When soldering, polish the excess. After having soldered both bends, the forking outlet must be polished.

Do so quickly polishing, emery grinding or scraping on a board or thick tile. The last step is to solder a nipple of about 3 cm on the forking, so as to obtain a well round shaped outlet in order to build the bell or screw thread. If you wish it to have an external screw thread, use a threaded nipple (Please see figs. 5 a, 6).



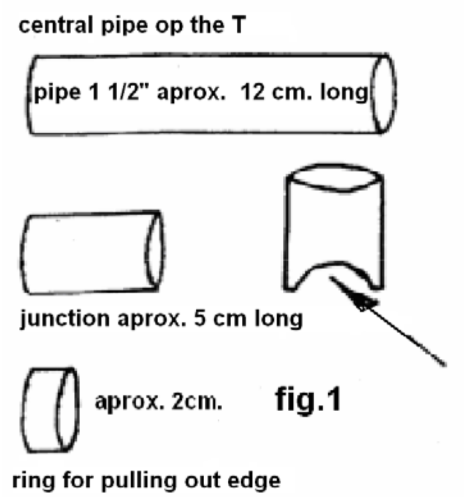




To build T's and Y's for drain pipes, we offer another technique. In this case soldering is not performed on a plate, but rather forking is arranged and soldered with adhesive.

<u>For an example we build a 1/2" drain pipe (sanitary) T.</u>

This technique can be used for all sorts of piping with all diameters and resistance. When dealing with PVC pipes with content of calcium carbonate (ground lime) the material loses some of its plasticity and the result you obtain is not very good.



From the bar, first we cut a 16 cm piece. This piece will be the central part or body of the T.

A 5 cm pipe will form the forking, and a 2 cm pipe will be the "core barrel" (Fig 1).

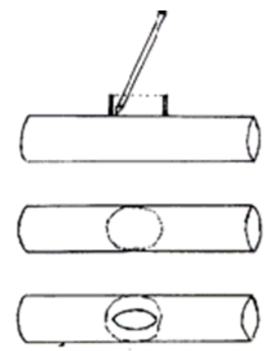
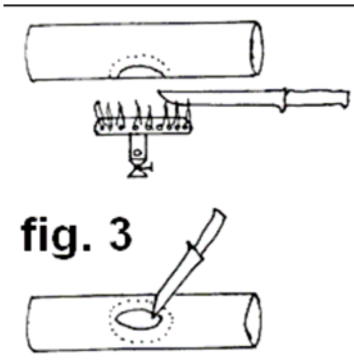


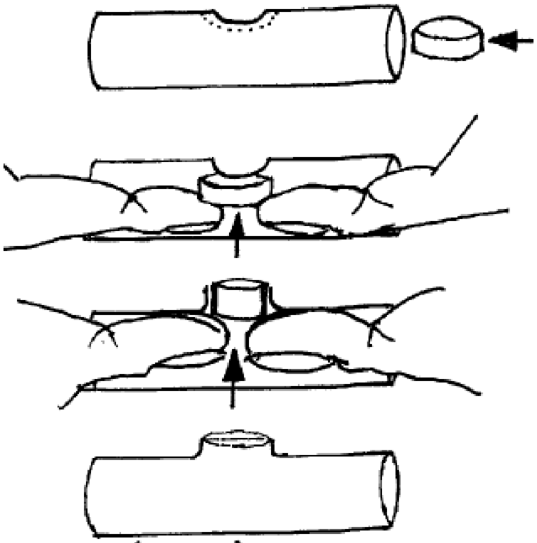
fig.2

Then take the central body and the core barrel and set the core barrel on the middle part of the body. With a pencil, mark the round shaped edge of the core barrel on the central body (Please see Fig 2). Theoretically this mark represents the hole of the forking. But we need a peak where to attach the forking on the body. We have to consider the material to be occupied by this peak when cutting the hole. For this purpose, build another mark, with an elliptical shape, entering on both sides every 0,6 cm.



Then take a sharp end knife. With a gas flame or a candle flame, heat the sharp end of the knife as well as the marked part of the body (Fig 3). When the hot knife has softened the marked part of the body, you can easily cut this marked part like cheese.

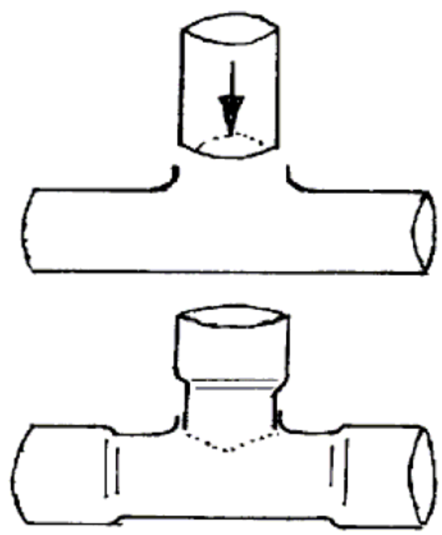
Once you have cut the marked part, get ready to draw out the core barrel. Heat again the marked part (only the marked part) and test its softening, quickly touching the plastic with your fingers (Fig 4).



(fig.5)

Then introduce sideways the core barrel ring into the body, with its peephole towards the hole. Arrange it at the middle part; introduce two fingers on both sides, and push the core barrel upwards. When the core barrel goes upwards, it will also raise the edge of the reserved material upwards, and thus it will form a peak. The core barrel is left in its place while it is cooled down with water.

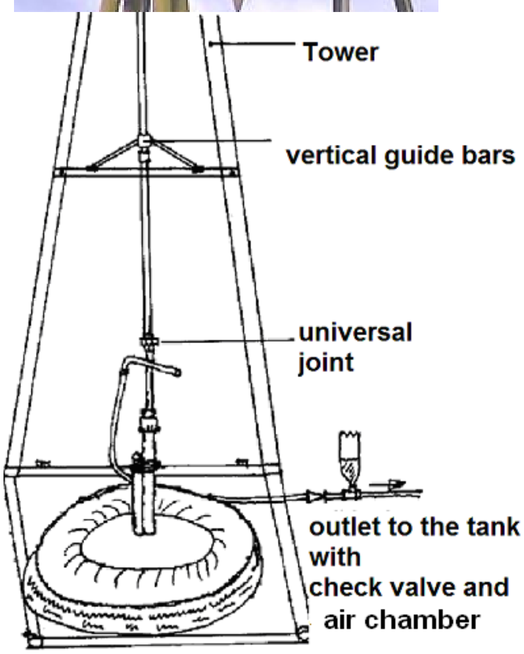
Finally draw aside the core barrel and introduce the forking pipe into the hole. To prevent the forking from being obstructed, set it in a semi round shape at its bottom (Please see Fig 1). Then spread PVC adhesive, and build the bells where they are needed.



(fig.6)

Windmill with the EMAS pump

The EMAS pump can be easily adapted to windmills. These mills may be simple, since no gear is necessary for pumping, and this means a higher yield and less investment cost. When you wish to convey water to a certain distance or height, use a pump with a thinner cylinder, and if you wish to have more volume, use a wider cylinder. The pump is easily adapted to different revolutions of the mill, making the course of the crankshaft longer or shorter. In zones with strong winds, or where mills have few wings, the revolution is increased, and therefore the course of the crankshaft should be shorter. In scarcely windy areas you find big mills which have many wings. Their revolution is generally slower, and therefore the course of the crankshaft can be increased.



To prevent wind overcharge and the mill from being damaged, most mills have an automatic safety latch. This safety latch is as follows : the revolving shaft of the sprinkling nozzle is located about 10 - 30 cm horizontally distant from the vertical shaft. Its tail end is fastened to the body of the sprinkling nozzle by a spring. The tail end is always oriented towards the wind, and it is located precisely behind the vertical shaft. When the wind speed increases to a certain limit, then also the wind pressure on the wings of the sprinkling nozzle is increased, and it surpasses the spring resistance. The sprinkling nozzle of the mill bends sidewise, separating itself from the wind and decreasing its speed. If the wind is even stronger, the sprinkling nozzle completely bends towards the wind, and an immobilization hook is hooked.

EMAS uses a pattern of windmill which cost does not exceed 300 US$/Euros. It is most useful for pumping drinkable water and for irrigation. The disadvantage of all windmills is that generally users are not prepared for their adequate maintenance. A windmill needs to be lubricated now and then, and whenever a piece is damaged, it must be replaced immediately. Otherwise all of it can be damaged in a short time, and the investment will be useless.

Considering these facts, it is more advisable to promote them only when an adequate maintenance is guaranteed. Otherwise, the choice of a manual pump will be more useful.

EMAS pattern solar heater with no tank

This pattern has been developed by EMAS specially for the Altiplano, where during winter nights frost is intense, and a beaming sun predominates during the day.

It is very expensive to protect water heaters from freezing, because special insulators are needed, as well as double and even triple glass. Another case would be to fill the water heater with anti freeze liquid and use a separate circuit.

This water heater needs no special protection from frost, because it is formed by wide piping which store such a large water volume that it is never fully frozen, not even during the coldest night.

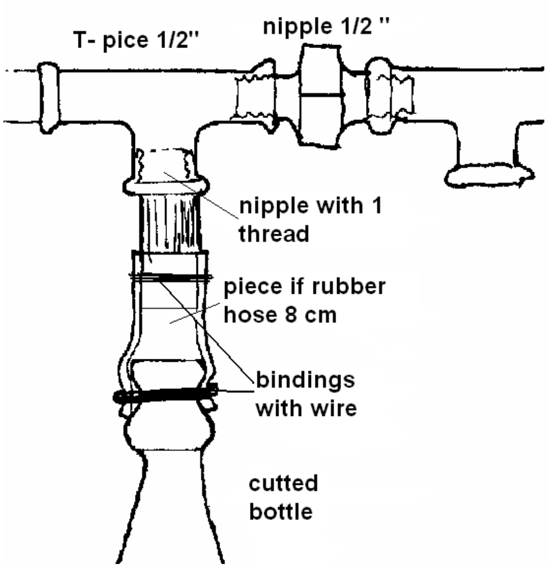
The following day, when the sun rises again, ice is quickly dissolved (if there was any) and water is heated. At about 10:00 a.m. you already have lukewarm water, and by noon it is burning hot. If this water heater is not connected to a tank, water cools down during the night. This disadvantage is prevented when having a separate deposit of hot water. It is easy to set up. You need 2" PVC sanitation pipes, bottles to be discarded, bends, T's, and 1/2" one screw thread nipples, pieces of PVC hose, lashing wire, paint and aluminum paper.

Also, a wooden box, and glass to be used for its cover.

The key for this water heater is that it a common PVC pipe can be use. Glass bottles serve very well as reducers, because heat does not deform them.

Besides, glass is corrosion resistant. To draw out the bottom of the bottle, set it for about 15 seconds in a pot with approximately 1/2 cm of oil.

Then rub with a moistened cloth the place where glass has been heated, and the bottom with instantly crack.



Then heat the sharp end of the 2" drain pipe to build a super wide bell. Widen the pipe with the same bottle, using its neck as ringer. Fitting the bottle inside the bell, the pipe should be slightly overheated so it contracts and presses the bottle. To prevent the pipe bell from being softened by the burning sun, producing leakage, tightly press them with several turns of acrylic thread Nº 40 or Nº 60.

Then set up the spreads with the T's and the hexagonal nipples; a bend is arranged at its extreme. A one screw thread nipple is screwed to the bellies of the T's. For a coupling between the spread and the bottle, use a piece of hose. First you have to heat it, in order to widen it, and then you must push it above the bottle neck. The side is fit into the well. When all the bottles have been connected to the Christmas tree and fastened with lashing wire, paint all of it in black. To prevent the hose couplings from burns, you can envelop them with aluminum paper. Finally set the box as per the measure of the wire screen bar and arrange the glass on top of it. Like all other water heaters, this model must have an inclination. Hot water intake is at its upper part, by the wire screen bar, and cold water intake is at its bottom. This system has been designed for a max. pressure of 1 meter water column, which means that is must be set up as indicated in the corresponding Figure.

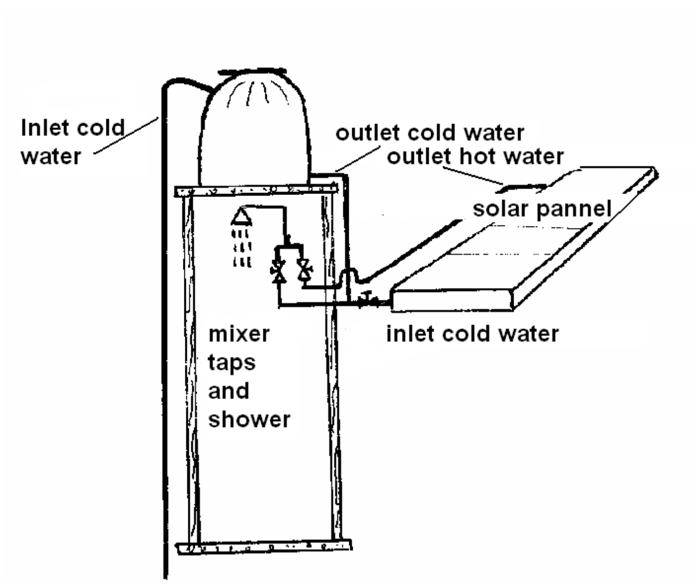
Two ways for changing a drum into a tank for hot water in a water heater

A 30 - 80 liters polyethylene drum can be used as a tank.

1st Manner : By means of plate soldering, polyethylene switches are soldered, reinforcing them. Reinforcing is obtained when using two nipples instead of one polyethylene pipe nipple, switching them in-between. One nipple is 1/2" and the other is 3/4". Thus you obtain a better contact for the solder made between the switches and the drum.

The other manner, whish is the best one, is to arrange an edge around the hole; therein, exerting pressure, switch a polyethylene nipple. With an approximately 2 mm bit , perforate a hole in the tank, at the place where you wish the switch to be set. Then, like pencil sharpening, make a sharp end to a stick, of about 10 cm length. The stick must be slightly thinner than the switch pipe; in our case 1/2". This piece is fastened on another broom stick, or even better, on the sharp end of a metallic bar, to form an L.

The next step is to heat the drum with a candle flame, around the small hole, until it softens a little. Take the stick, introduce it into the drum and from its inside part, push its sharp end outwards. You will thus widen the small hole until the measure of the stick, and at the same time an edge will be formed outwards. Then let the plastic cool down, remove the stick and with pressure, insert the switch pipe. To increase the resistance you can tie this peak with Nº 40 or Nº 60 acrylic thread. When open barrels are used instead of drums, it is easier to draw the edge.



The polyethylene drum is corrosion resistant, and it is also resistant to hot water temperature. The water heater system is the same as already explained.