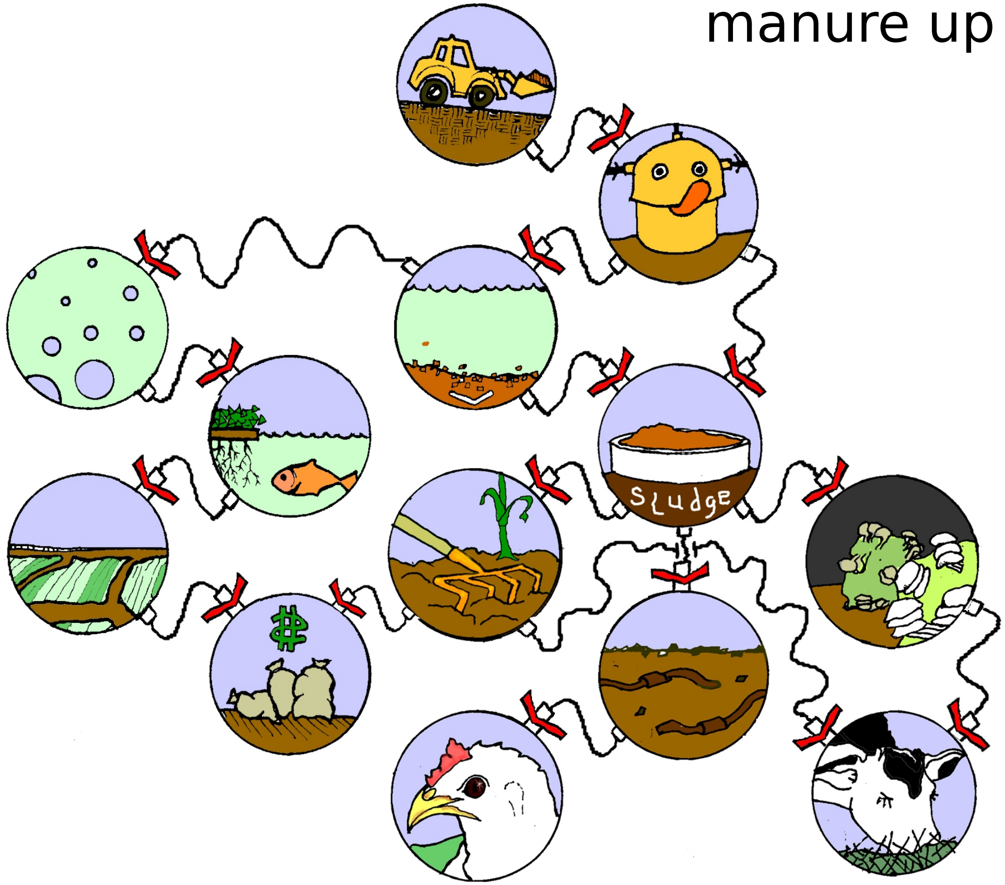
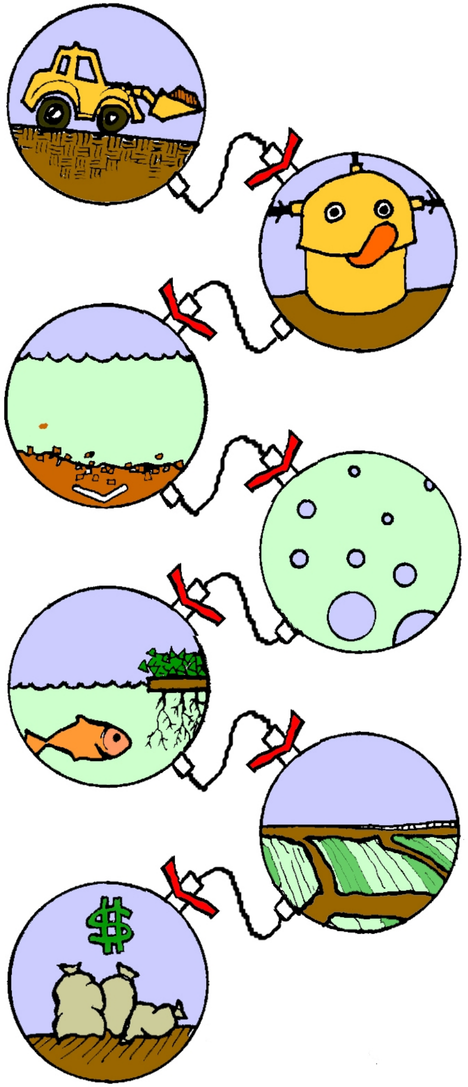
✓Natural **anaerobic** and **aerobic** processes used in series obtain maximum yields of energy, fertilizers and crops while treating the livestock manure up to 100%.



✓**Integrated Farming and Biomass Systems** completely treat all livestock and animal waste economically and ecologically, with savings to the local government authority and substantial profits for the farmer.

The Integrated Farming System



✓**Collection** – gathering all materials

✓**Digestion** – anaerobic (no oxygen) process in which microorganisms and bacteria break down animal (including human) waste. Methane is created for use as energy. BOD reduction – 60%

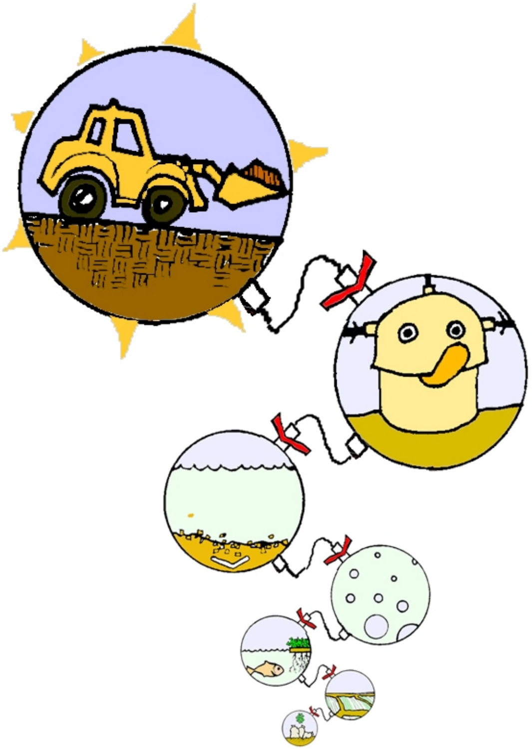
✓**Sedimentation** – process by which heavy organic particles are allowed to settle, allowing more thoughroughly digested (and therefore lighter) particles to continue to the next process, while the other sediments continue to break down into sludge.

✓**Aeration** – process by which oxygen is mechanically aspirated into the water to aid in the metabolic process of aerobic microorganisms (algae and fungi) and bacteria. BOD red. – 30%

✓**Pond** – aerated water and nutrients (waste products of microorganisms and bacteria) are eaten by plants and animals, which can then be harvested for food. Remaining BOD reduction of 10%.

✓**Irrigation** – nutrient balanced water can be added to crops directly, saving water.

✓**Harvest** – crops are harvested and sold.



Collection involves figuring out how to get your agricultural or livestock “wastes” from where they occur, to the next point of this process.

Do you have wastes that you are paying to throw away?

If they are an agricultural byproduct, or from livestock, you are currently throwing away a very valuable resource.

Are your livestock in open or closed pens?

If they are outside, what environmental issues might impact the transport of manure?

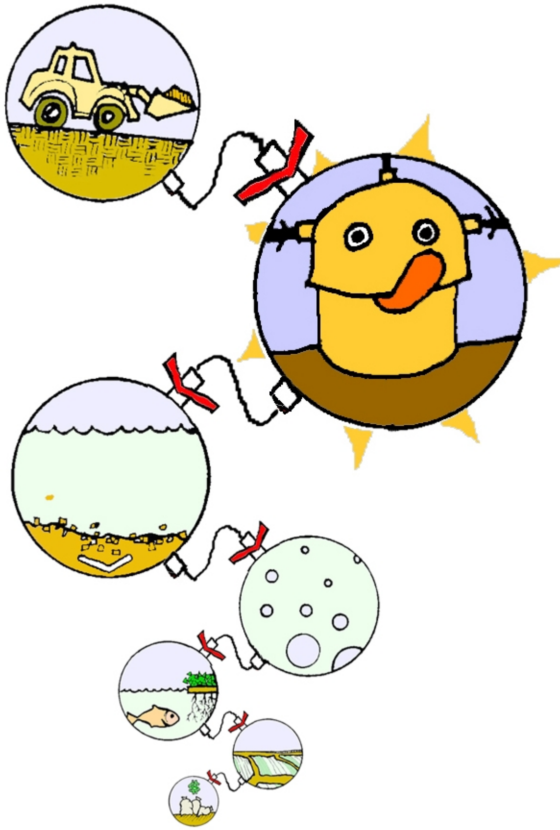
Are they on earth or concrete?

Are they natural or constructed drainage facilities?

In the case of human waste (night soil), what sort of plumbing do you have?

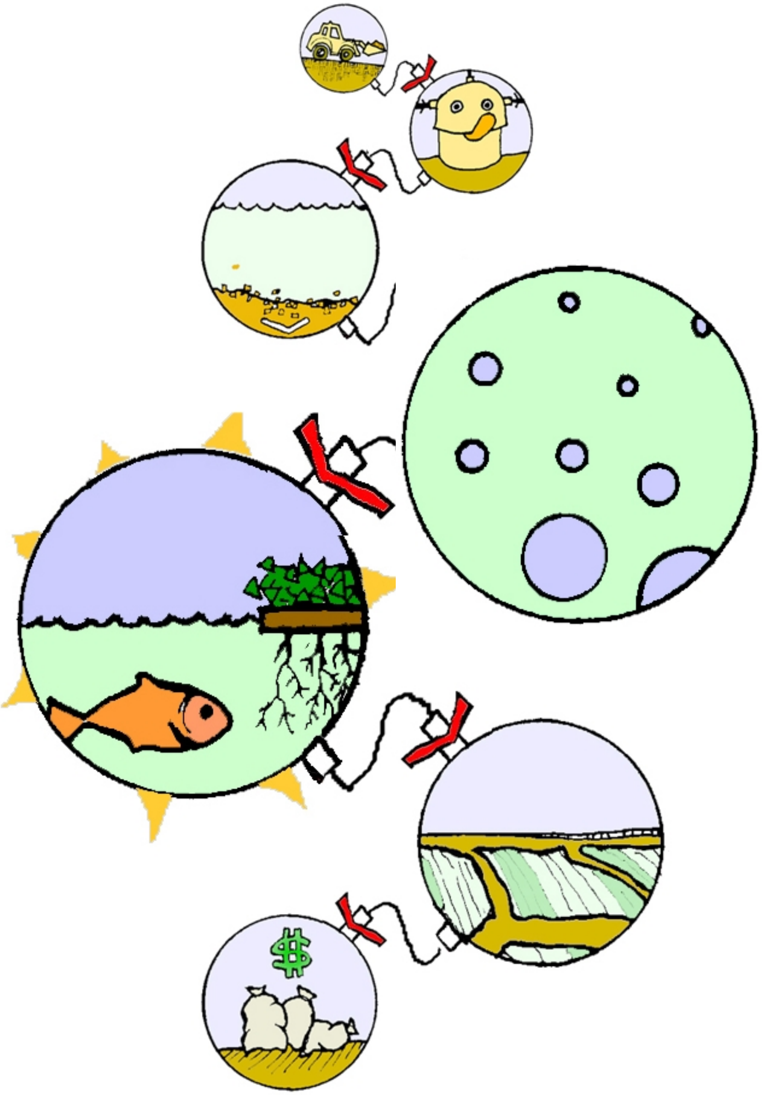
In the case of agricultural biomass, what is the carbon/nitrogen ratio?

These kinds of questions are important in determining the most economical infrastructure needs in order to best facilitate the transport of night soil, manure or agricultural biomass, to the anaerobic digester.



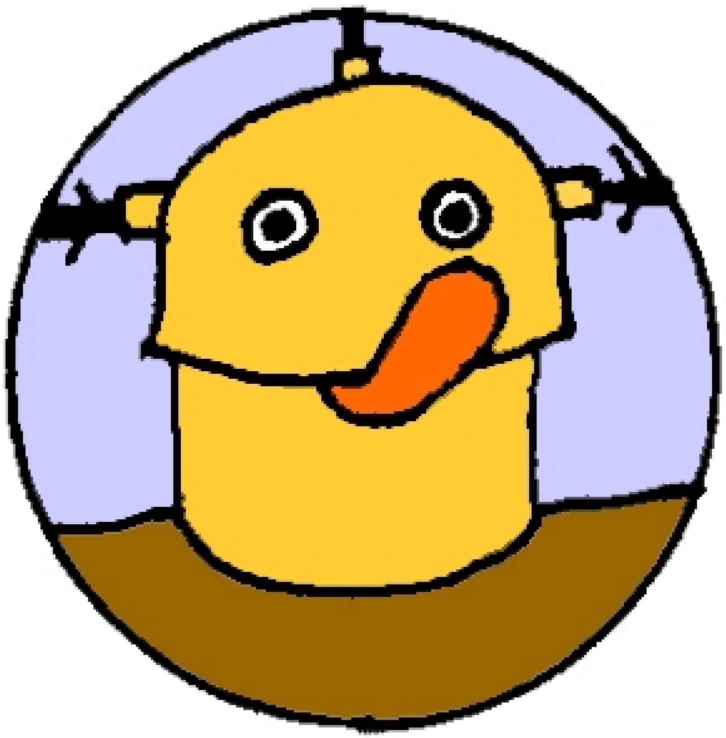
The **anaerobic digester** is the heart of the SERI Integrated farming and Biomass Systems. Without the digester, other processes will take longer and not be as efficient or effective.

In fact, the digester allows four(**4**) main groups of bacteria to alter the more complex organic materials into simple molecules (nutrients) that are ready for consumption by algae and macrophytes



The **oxidation basins** and the **pond** are both **aerobic processes** where the digestion of organic matter and inorganic nutrients continues.

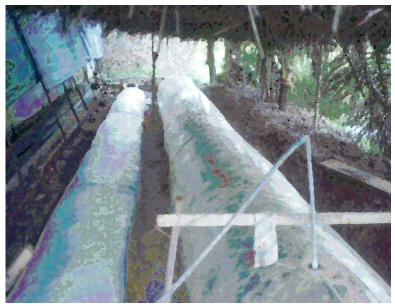
By the time the water leaves the pond, the waste has gone through 100% nitrification, and is ready for use in irrigation.



An efficient digester should remove over 60% of the Biochemical Oxygen Demand (BOD) of incoming livestock wastes within 3-6 days. The digester is suitable for very high organic loading as seen with livestock and agro-industrial wastes.





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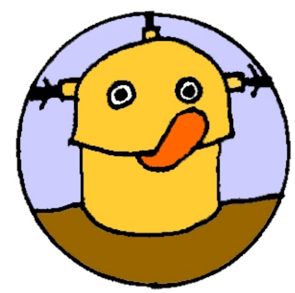
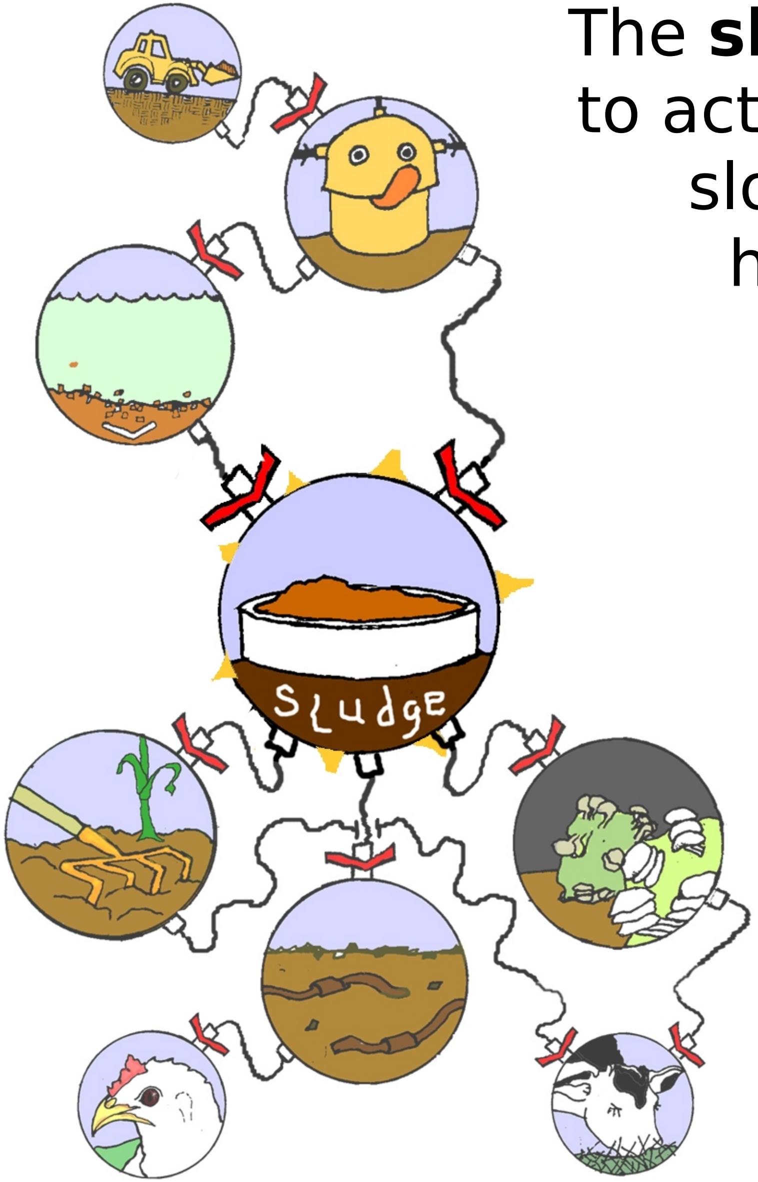


The most effective biodigester design is the Up-flow Anaerobic Sludge Blanket, with a double wall for circulation of waste steam or hot water to increase temperature.

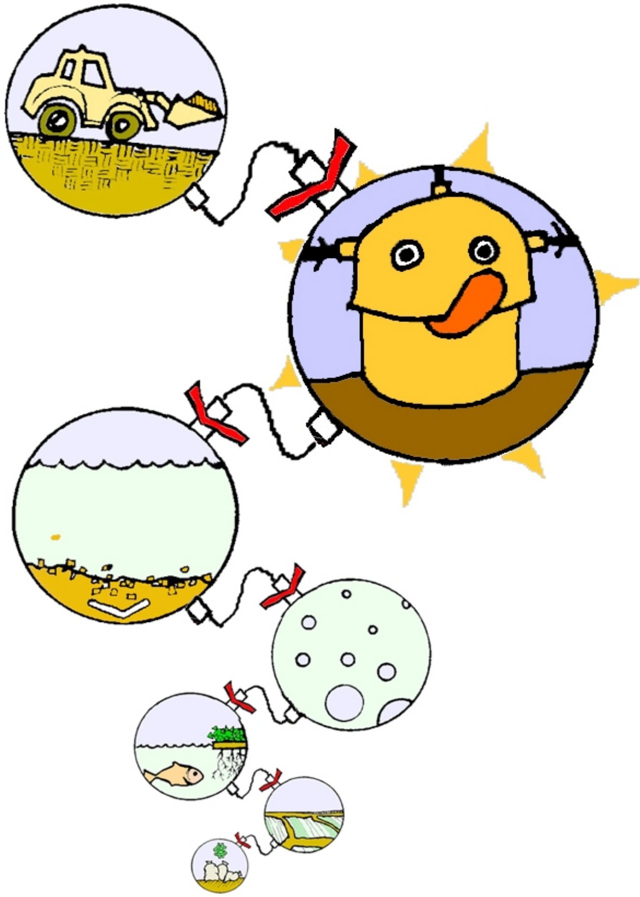
The digester, being the most important equipment of the Integrated Biomass or Farming System, is given more attention. For the small & medium sizes, the farmer may design & build his own digester, but it is advisable if he seeks professional & especially structural engineering design data when necessary. For commercial & industrial plants, it is <u>mandatory</u> that the whole process be professionally done.

The **sludge** stays inside the digester to act as an anaerobic blanket which slows down the movement of the heavier particles in the effluent.



The longer solids retention time in the digester breaks down the sludge more effectively and efficiently than conventional hydraulic methods.

This stabilized sludge is removed from the sedimentation basins and the digester tank regularly for use as compost, earthworm and mushroom cultivation.

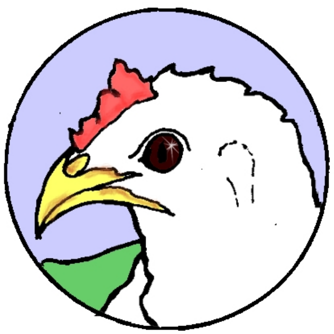


DESIGN DATA
(besides those already descrbed)

TEMPERATURE
Mesophilic - 35oC (1-2m3 biogas/m3 of digester)
Thermophilic 55oC (3-5m3 biogas/m3 of digester)
(highly sensitive)

HEATING
Heat Transfer (solar)
Heat Transfer (biogas)
Heat transfer (electric)

LOADING RATE
Kg BOD/m3/day = 10 to 20
Kg COD/m3/day = 20 to 40



Livestock Wastes

(kg per day)

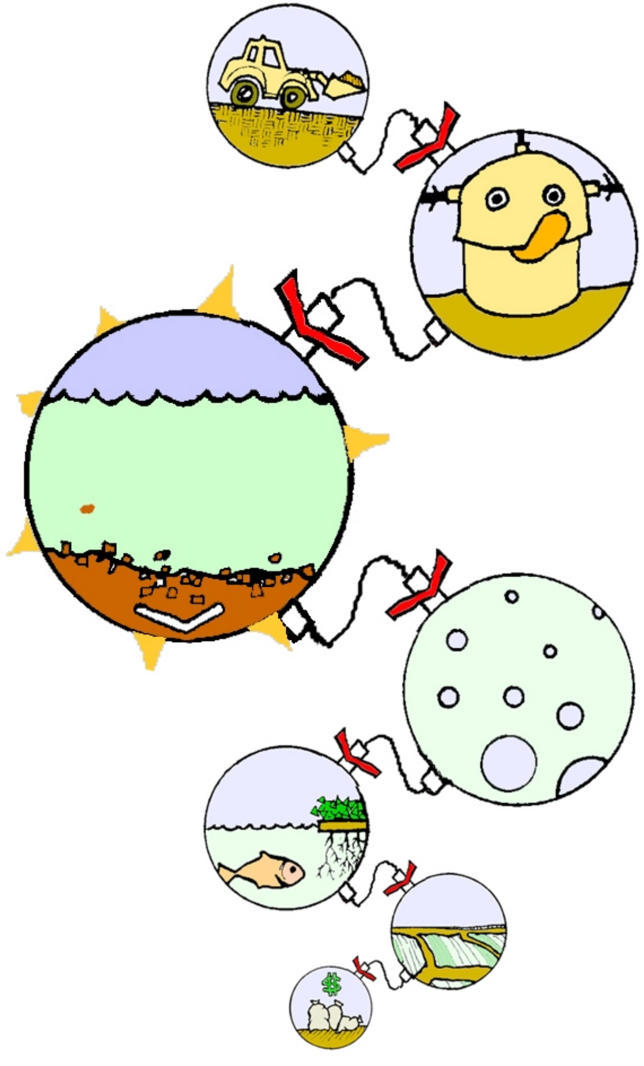
Cattle (calf)	5
Cattle (1 year)	10
Cattle (stock)	25
Heifer	15
Young Cow	20
Dairy Cow / Bull	40
Piglets/Fattener	2
Fatteners	5
Dry Sow / Boar	10
Broiler	.05
Duck	.04
Goose	.55
Layers	.11
Turkeys	

EXAMPLES of BOD (mg/l)

Cattle	2,000
Pigs	3,000
Beef Factory	250
Pork/Others	2,000
Dairy	2,500
Fruit Factory	1,000
Sugar Mill	1,000
Breweries	1,000
Oil Palm	12,000
Distillery	20,000

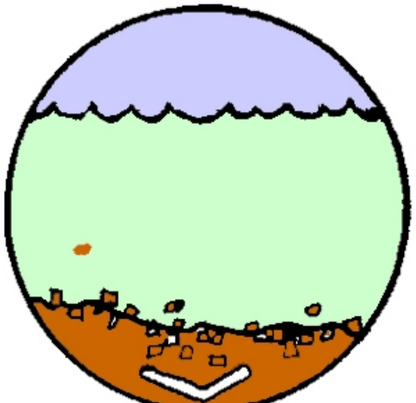
GENERAL

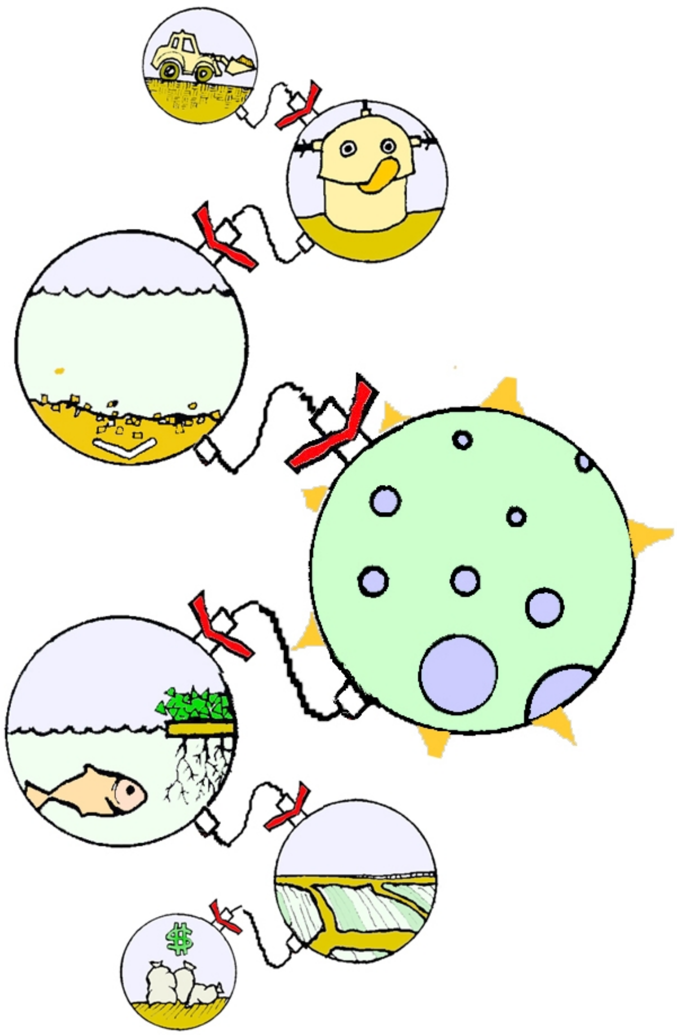
Sewage	300-400
Industry	1000-2000



The anaerobic digestion of the 'waste' is followed by a **sedimentation process**, where heavier material is allowed to precipitate allowing water infused with other lighter materials and organisms to flow to the oxidation basins and ponds.

Sedimentation tanks can be built with numerous easily accessible materials.

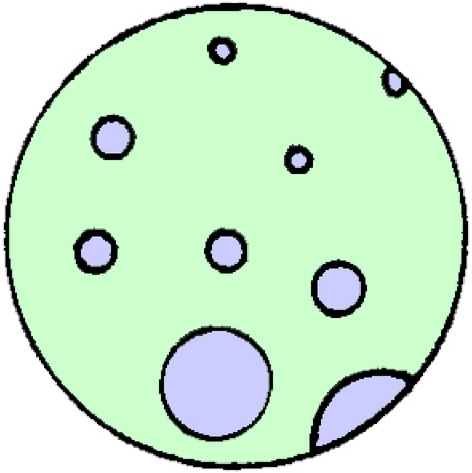




- ✓By the time the effluent leaves the digester, it still has up to 40% of the original organic content.
- ✓It has a much lower BOD or COD load, and can therefore be handled by aerobic processes and algae growth (algae produces oxygen) in **oxidation basins**. Here, 75% of the remaining BOD and COD loads are taken care of. The remaining BOD and COD loads (10% of the original) will be completely digested in the upcoming pond environment.

HARVESTING

1. LIVE algae harvested a few times a day as high-protein feed supplement.
2. DEAD algae harvested daily as compost for mushroom culture.
3. Photovoltaic pump and/or biogas-operated compressor used for the circulation of liquid and the removal of all organics before entering the pond.
4. Only well-oxidized and nitrified liquid should enter the fish pond.



BENEFITS of SHALLOW BASINS

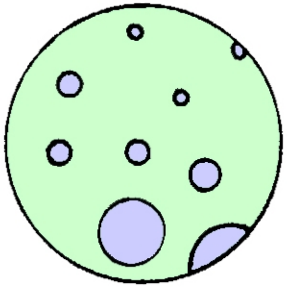
(i). Reduction of livestock wastes entering the POND: Less use of dissolved OXYGEN in the pond for the Benefits of the FISH .

(ii). Removal of most algae, LIVE or DEAD before entering POND to prevent EUTROPHICATION.

(iii). Effluent entering pond water has HIGH dissolved oxygen content to benefit the fish.

(iv). Also adequate nutrients for prolific growth of various PLANKTON as fish feeds.

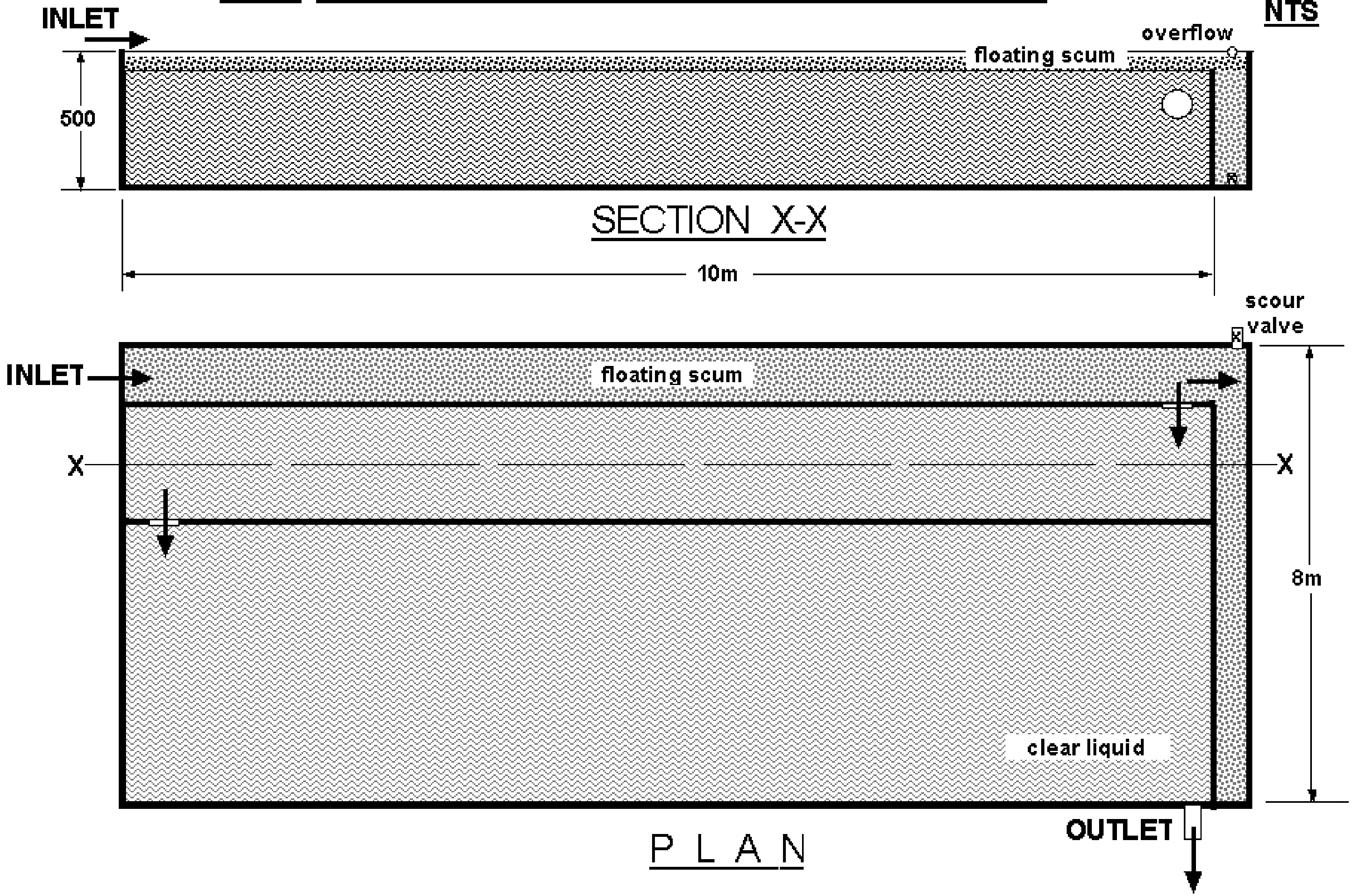
In the tropics, it has been found that on a sunny day, the basins perform on their own generating sufficient oxygen in the water for all necessary biological processes. The sun, in many cases, will do most of the work, and should be supplemented by a pump or compressed air system. In the last oxidation basin, it is preferable, if oxygen is to be added manually, to add it close to the outlet to the ponds.

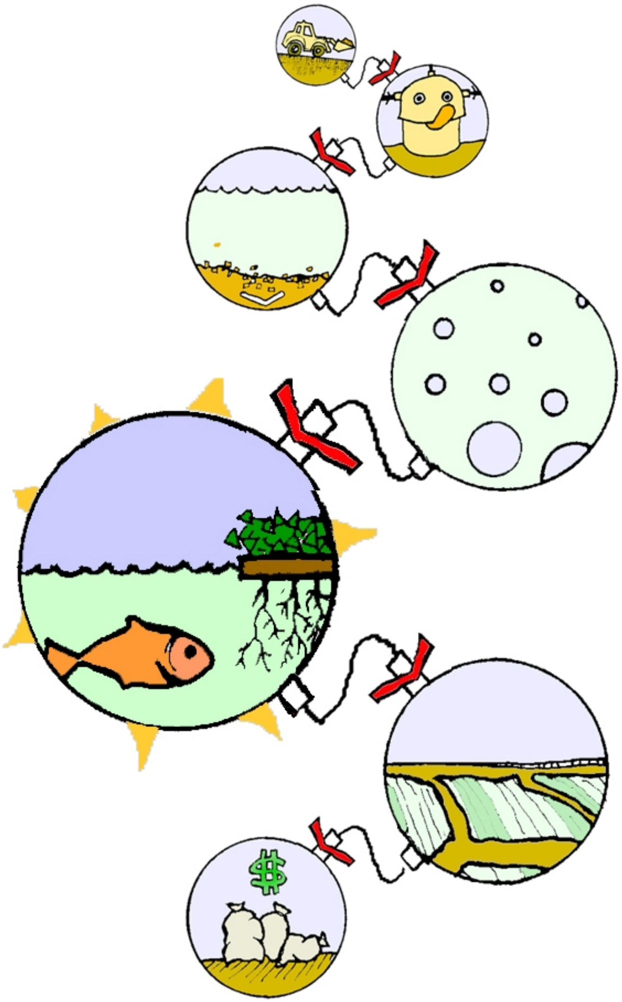


Picuri sD03
chanbio7-2

40 m³ OXIDATION BASINS for PICURIS PUEBLO

Fig. 3
NTS





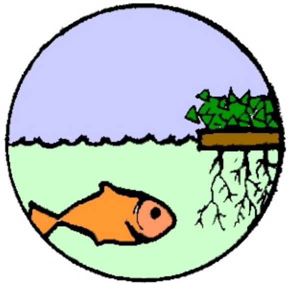
In order to obtain maximum yields of different fish in **pond polyculture**, the by products created by the pond system, must be used maximally.

Fishes produce their own wastes that are naturally treated by orthotropic and heterotrophic organisms in the pond.

They, in turn, excrete as waste a second cycle of nutrients which fertilize aquaponic crops on floats in the water, and the crops surrounding the ponds.

(As in the example of China, and the large area of dykes they incorporate for crop growing).

All nutrients produced in the pond, must be utilized in the pond to avoid pollution through Eutrophication.

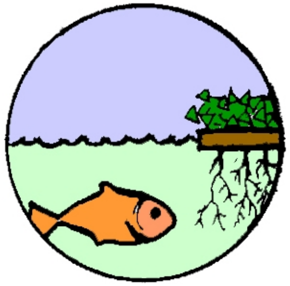


The ponds should be as large and deep as feasible, in order to provide the best environment for the growing of fish. The pond environment, having been buffered by the digester, sedimentation basins, and oxidation basins, is the most stable environment, and would not be affected much by small changes in livestock quantities.

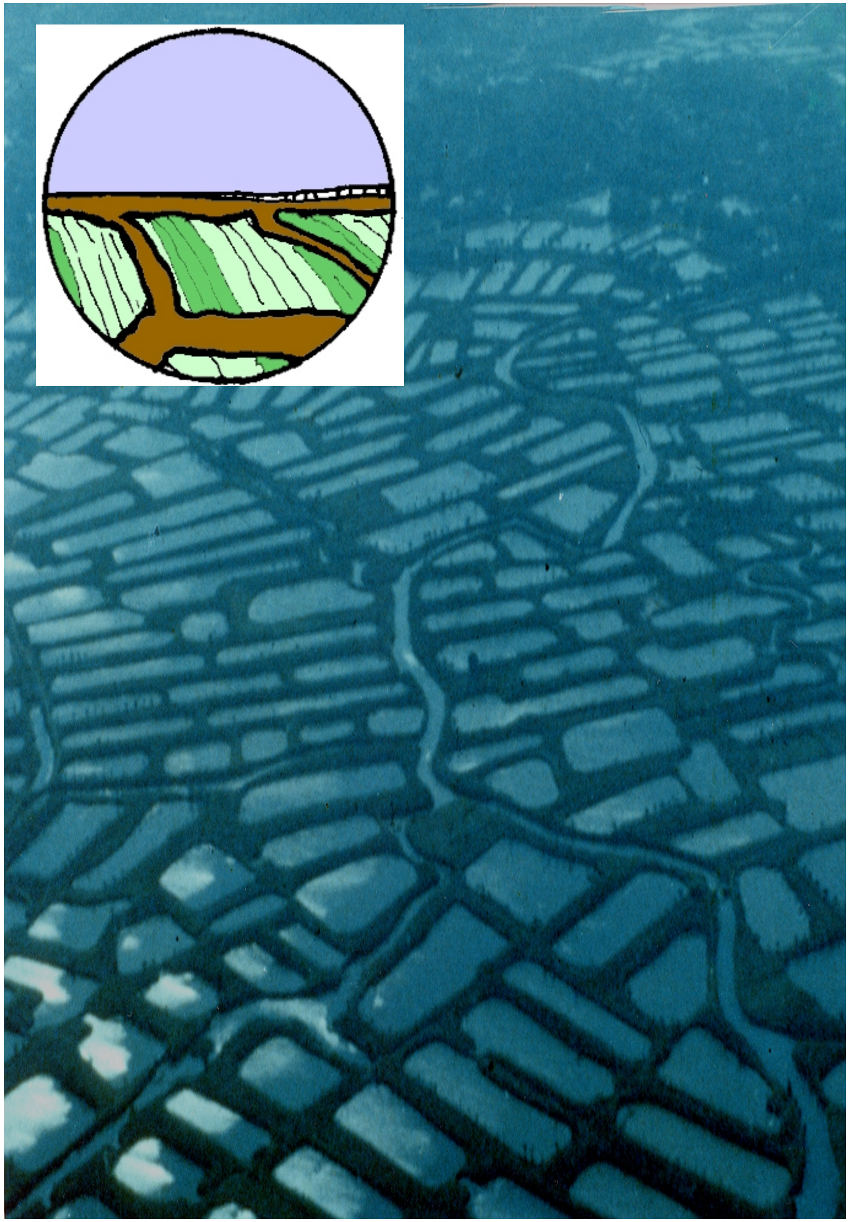
Up to half of the surface of the ponds (more if there is diffused air in the ponds) can be covered with aquaponic crops on floats.

The dykes surrounding the pond can be covered with polyculture of various crops and need minimal attention.

Biodiversity on the dykes of ponds ensures natural control of pests without the need for toxic chemicals. Occasionally, one prevalent pest, feeding on a specific crop (10% of total harvest) will take over, but will also often keep any other pests away. Think of it like a small tax. Multicroping on the dykes of the ponds have made many ponds look like jungles.



Biological and natural means, such as drying, smoking, salting, pickling, etc., are the best when processing of produce. There is also a rich heritage of revived, culturally passed down processing methods that we have yet to tap completely. These cultural gems, if not rediscovered soon, could be lost for ever. Preservation methods can be of tremendous service to a farmer who is having difficulty selling his produce because of a glut in the market. They enable the farmer to save the produce, and to avoid selling it off too cheap. This excess of crops, if preserved, would in many cases retain their market value.

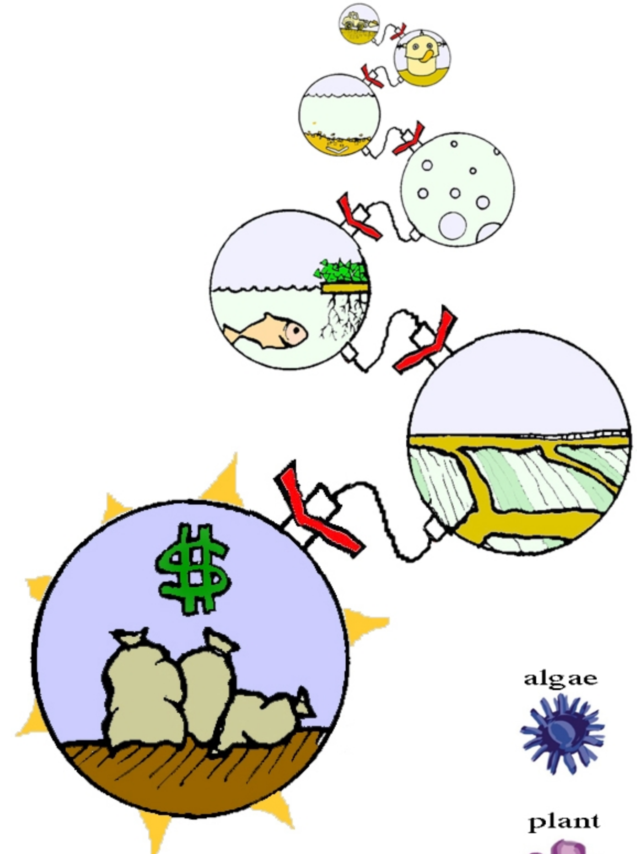


Some dykes, such as the example in China discussed earlier, have a variety of levels and trenches that serve the cultivation of different crops.

Vegetables, with shorter root systems, can be grown in the trenches while fruit trees with longer roots (such as bananas and papayas) are planted on higher ground.

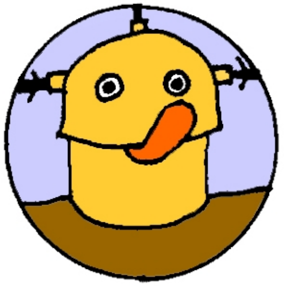
Because they are deriving their water from the close-by aquifer produced by the ponds, they require the very minimum of maintenance.


harvest




algae
plant
animal
bacteria
fungus

Cost



The most important but costly methods treatment is the **anaerobic process;** with the addition of as many less expensive (and effective) aerobic processes as is affordable.

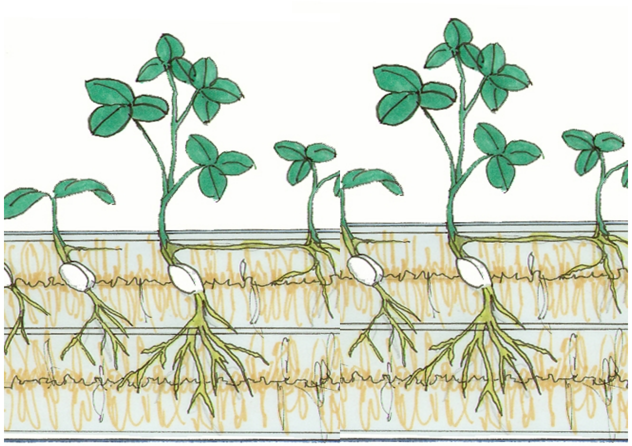
Other costs include the purchase and use of additional mechanical and electrical devises (such as pumps or heaters) which can be used to enhance these processes. However, keep in mind that there are often solutions which are more effective and less expensive than these devises (including making use of gravity instead of pumps, and the suns heat instead of heaters).

Hidden Costs with Aerobic Processes Exclusively

✓When used exclusively as seen in most sewage treatment plants worldwide, are **very expensive** (including: primary settling, activated sludge, secondary settling, and trickling filter technologies).

✓This is because the 4 groups of anaerobic, methanogenic (oxygen hating, methane producing) bacteria cannot live in environments saturated mostly by oxygen.

{Remember.... from Before:}



Anaerobic methanogenic bacteria provide an essential function in the complete breakdown of certain difficult wastes, and in the elimination of pathogens. Activated sludge processes are particularly expensive because of the duplicate set of tanks required, and the energy expenditure this addition represents. Aerobic processes transform organic material into inorganic nutrients using oxygen in the water. Oxygen must often be pumped or blown into the water during this phase (unless you incorporate the use of gravity fed waterfalls and oxygen producing organisms such as algae).

Anaerobic processes **can be** less expensive. Especially with regard to animal waste which are much more concentrated than plant wastes, and also take up less volume. Anaerobic processes, as a result, require much smaller and therefore less expensive, air tight tanks (digesters). The digesters are designed with Up flow Anaerobic Sludge Blanket (UASB) Technology, which increases their efficiency over conventional digesters.

What makes anaerobic processes generally more expensive are the costs of building the custom, air tight tanks, and the infrastructure of gas collection (although, again, there are solutions to both that utilize inexpensive and very basic appropriate technologies).

The smaller your tanks are, the less retention time their is for the material. The less retention time for the material, the lower the digestion and BOD (Biochemical Oxygen Demand)/COD (Chemical Oxygen Demand). reduction. The key is to have the anaerobic processes used as 'pretreatment' followed by a series of inexpensive aerobic procedures.

Economic Evaluation of the Integrated Farming and Biomass Systems

Gavilanes Hacienda

Pereira, Columbia

(Based on real prices)

- ✓100 sows + 1,000 pigs on farm at any time.
- ✓Yearly Production: 2,000 pigs
- ✓Value per Pig: $150 U.S.D.
- ✓Capital Needed for Farm: $300,000 U.S.D.
- ✓Savings on Feed: 70%
- ✓Savings on other expenses: 20%
- ✓Gross Profit: $30,000 total.
- ✓Profit /Head: $15 (yikes!)

If the Gross Capital Investment for the projected cost of the farm,

($300,000)

is borrowed From a Bank at **10%** yearly interest…

…The farmer will never make a profit.

Cost of Same Farm with Integrated Farming and Biomass Systems

Pereira, Columbia

(Based on real prices)

✓Digester:	$40,000
✓Shallow Basins:	$5,000
✓Fish Ponds:	$30,000
✓Accessories:	$5,000
✓**Total Needed Capital**	**$80,000**

sustainable communities
ZERI new mexico

The Farmer can expect a savings of:

- ✓ **40% on Feed Costs – First Year**
- ✓ **70% on feed Costs – Second Year**
- ✓ **100% on Feed Costs – Third Year**

The farmer can expect a savings on Fuel, Fertilizer, and Labor of:

- ✓ **50% - Every Year**

Incredible!

Savings in the First Year:

40% of $210,000 =	**$84,000**
50% of $60,000 =	**$30,000**
Total =	**$114,000**

sustainable communities
ZERI new mexico

Water Use:

- ✓use per Pig: 10 liters
- ✓@ 1,000 Pigs: 10,000 Liters / Day
- ✓@ 3 days RT: 36m3 (Digester Size Minimum)

Energy Production:

1,000 Pigs @ 2kg (Piglets)

or 1,000 Pigs @ 5kg = 5,000 kg

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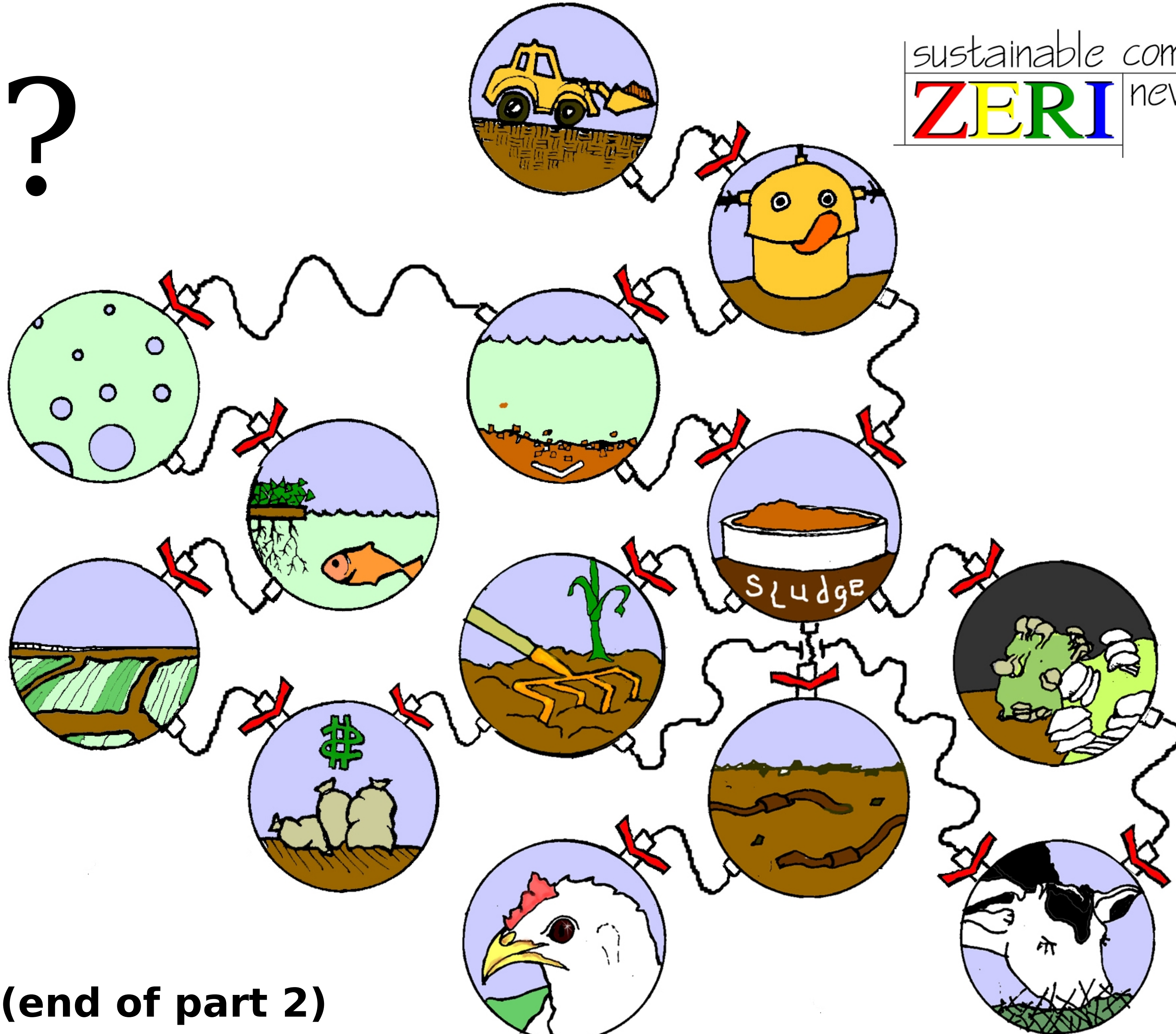

(end of part 2)