Irrigating with animal manure water

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1. Introduction

Livestock manure is a resource that can be a valuable asset to your farming operation if it is used and managed appropriately. However, when if it is not carefully managed in order to minimize odor, nutrient losses and emissions, it can become a source of pollution and a threat to aquifers and surface waters.

One of the methods of using animal manure as fertiliser, is to apply it in a liquid form to crops. This can be applied to large scale and small scale farming operations engaging in either intensive or extensive animal husbandry practices.

The scale of the animal farming operation and whether it is an intensive or extensive operation has an influence on the approach being followed in using the manure water for irrigation. This article focuses mainly on the use of manure water derived from intensive animal husbandry systems. The application of animal manure water in small scale farming operations will be discussed briefly.

2. Background

In intensive animal farming practices animals, mostly pigs, dairy cattle and sometimes poultry, are housed indoors or in relatively small areas. The manure produced by the animals is washed away at regular intervals into a specially designed pond or preferably two ponds in series, where it is anaerobically stabilized before it is used for irrigation.

The volumes of manure water from specific animal housing systems depend on the cleaning method used. It will determine the percentage solids in the manure and the total volume of water flowing from the system. The large volumes of manure water can pose a problem to the environment unless they are disposed of properly. Estimates of waste produced are given in Table 1.

Table 1 Annual manure production (Livestock waste facilities handbook, 1985)

Animal	Manure production per 450 kg animal mass	
	Dry manure mass (ton / y)	Manure volume (ℓ / y)
Dairy cow	6,8	13 700
Feedlot bovine	5,0	10 400
Pig (feed)	8,2	16 600
Pig (breed)	2,0	5 800
Sheep	3,4	6 350
Layer hen	4,5	8 850
Broiler	5,9	11 900
Horse	3,9	7 750

Figure 1: Intensive animal housing

2.1. The main factors to consider when irrigating with animal manure water

2.1.1. Water quality

Water analysis is essential for effective manure water management and application. The correct interpretation of the water quality with which the irrigation is to be done is very important in the entire planning- and management processes. The water quality influences the growth of the plants, soil characteristics, biological balance in the soil and it also has an influence on the irrigation equipment used. The classification of irrigation water takes place according to the physical, organic and chemical composition thereof. Certain problems such as e.g. salinity and infiltration reduction can arise or worsen if the used irrigation water's quality characteristics exceed certain border values.

- Chemical characteristics
  The chemical characteristics of soil can be significantly changed by the addition of animal manure water.

  Except for the macro- and micro elements present in the manure water, animal manure water can also contain high salt concentrations. Irrigation with high salt concentration water can lead to the build-up of salts in the soil, which can lead to crop damage. The use of irrigation water with high salt concentration can require additional managerial inputs to limit salt build-up in the soil. Due to the fact that there are heavy metals present in animal rations, the build-up of heavy metals in the soil must be monitored together with the soil analyses. The choice of crops that are to be irrigated with manure water must consider these factors.

- Organic chemicals in manure water
  The presence of various insecticides and organic chemicals in manure water must be monitored in order to prevent to environmental and health risks.

2.1.2. Soil characteristics

A proper soil analysis is very important for the efficient management and application of manure water. The soil is the natural storage place of all plant nutrients. Soil is also the receiver of various

waste products, which causes its breakdown or binding and results in the incorporation thereof into the natural cycle. Soil is the most important element in recirculation in the environment and the natural cycle.

Pollution occurs when application exceeds the normal conversion time of certain chemical elements. Exceeding of the conversion time leads to the build-up of certain elements and a resulting negative effect, such as the degradation of the soil structure. The pollution of soil can lead to the deterioration of soil and surface water quality.

The following physical characteristics have an influence on the irrigability of the soil:

- Physical characteristics
    - Infiltration rate
    - Water retaining ability
    - Drainage characteristics
    - Porosity
    - Effective soil depth
    - Soil structure
    - Soil texture

- Chemical characteristics of salinity (brackishness)
    - Nutrient elements
    - Sodium adsorption ability
    - pH
- Biological characteristics
  Manure applications can considerably improve the biological characteristics of the soil. The micro-flora populations of the soil (bacteria, fungi, ammonia formers and nitrate formers) can be considerably increased by the application of manure.

If any doubt exists regarding the irrigation potential of the soil, a soil scientist should be consulted for the necessary recommendations.

2.1.3. Hydrological factors

The topography of the area where the facility is to be erected, the climatic factors, distances from open water streams, possible positions of storage facilities and soil type play an important role. The construction of the storm water control system is necessary to control runoff that can occur during rainstorms and keep it out of manure dams. The manure dams must be prevented from overflowing of into streams and rivers.

2.1.4. Climatic factors

The factors that play a role are total rainfall, rainfall intensity, rainfall distribution pattern, evaporation, prevailing temperatures and prevailing winds. The total rainfall determines the volume of water that must potentially be handled by the manure dams or leaching of salts that will occur as a result of the rain. The rainfall distribution pattern will have an influence on the hydrology and the irrigation management. Evaporation has an influence on the rate at which the biological breakdown takes place in the manure dams and therefore also on the possible odour problems. Evaporation is a factor that plays a role in the rate at which the salt concentration in a manure dam increases.

2.1.5. Environmental Factors

The closeness of urban or built-up areas and the prevailing wind directions play a definite role in the planning of waste handling facilities. The question of fly nuisance and bad odours must also be kept in mind if the facility is close to an urban area.

2.1.6. Availability of irrigation water

The availability of irrigation water to ensure the irrigation of crops and for the dilution of manure water must be determined. If the water source is a storage dam, a water balance can be necessary to ensure irrigation throughout the year. In Table 2 the volumes of flushing water needed for the intensive housing of different animals are shown.

Table 2 Minimum total daily flushing water volume required

Type of animal	Flushing water volume (ℓ/ animal/day)
Pigs	
Sow and litter	130
Suckling	15
Grower	60
Finisher	95
Dairy cow	380
Feedlot ox	380

Figure 2: Concrete channel for flushing manure water to manure pond

3. Management requirements and guidelines

It can be seen in the points mentioned above, that high management inputs are necessary for the safe and effective use of manure water to irrigate crops. Points to be noted in an effective plan are noted discussed below/

3.1. Soil

Electrical conductivity (EC) of the soil and manure water should be determined regularly to identify potential problems in time. It gives a good indication of the levels of salts in the tested water and soil.

3.2 Equipment

- The electrical motor at the pump must be earthed thoroughly to help combat the problems of electrolysis or depositing of salts in the irrigation system.
- Cleaning of equipment – flushing of the irrigation equipment with clean water before and after irrigation is essential to protect the equipment against the aggressive corrosiveness of the manure water. During irrigation with manure water, care must be taken that nozzles are cleaned regularly to prevent blockages and uneven applications.
- Where clean water is used for diluting manure water, equipment must be in place to avoid contamination of the clean water source.
- A suitable water flow meter on the delivery side of the pump is a necessary item for the effective management of the system.

3.3 Irrigation

- Regular measuring of the pH-values will give a good indication of the possible build-up of salts. High salt concentrations are reflected by high pH-values. The pH-values of anaerobic manure dams must be maintained at between 6.8 and 7.8.
- Irrigation must preferably not be applied closer than 35m from open streams, dams, open ditches, etc.
- Application of manure water on over-saturated soil on which free water occurs must be avoided, especially if runoff occurs.
- Irrigating with manure water during the heat of the day with overhead irrigation systems must be avoided to prevent leaf-burn damage. Irrigation of the crops with clean water at the end of the cycle will also limit possible crop damage such as leaf-burn.
- In drier areas where irrigation is done with manure water, leaching of the root zone must be done during the year to prevent the accumulation of salts.
- The use of micro and drip irrigation systems for application of animal manure water must be approached with the greatest care, especially regarding possible blockage problems and salt depositing in the systems. The presence of nutrients in the water is beneficial for bacterial growth. An effective management plan that includes the flushing of the system at the end of each block's irrigation time must be followed.

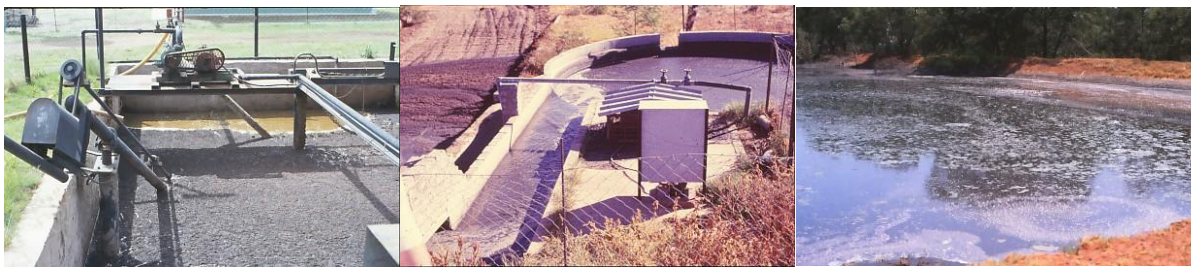

Figure 3: Typical manure ponds

3.2. Health Regulations

Consult with the local authorities regarding the health regulations to determine what the relevant requirements are. It is very important to adhere to it, especially regarding the irrigation of edible vegetables and crops with manure water.

3.3. The Influence of irrigation with manure water on the soil, water and plant relations

The characteristic of soil to re-circulate nutrients, is utilised by the application of manure water and possible costs on manure processing plants are mainly avoided.

Large intensive animal housing systems can sometimes have the disadvantage of too much waste for the available irrigable area. The result can be repeated application of manure or manure water on the specific area. This can cause a reduction in the fertility of the soil by:

- Reduction in crop yield as a result of an excess of nutrients.
- Pollution of subsurface water as a result of the leaching of nitrates, nitrites, salts, micro-organisms, etc.
- Pollution of the surface water as a result of the runoff of organic materials, salts, chemicals, etc.
- Damage to soil characteristics such as pH, structure and salt content.

Analyses of the soil and water must be done at least once per year during the cultivation season to serve as warning for any possible build-up of undesirable elements.

3.4. Equipment and infrastructure

For wet manure handling, there are basically two processes for the biological breakdown of manure water, namely the aerobic and anaerobic processes.

- The aerobic process requires a large amount of energy to be added to the process. The benefit of this process is that it is almost odourless and that less storage facilities are necessary than with anaerobic processes. It is however much more expensive than the anaerobic process and is used mainly by municipalities.
- The anaerobic process is mostly found on farms and consists of canals, single or double manure dams, pump sumps, separators and a sieve system.

3.4.1. Manure storage dam design considerations

Some considerations in manure dam design are:

- Position - usually determined by the proximity of homes, slope and distance from open streams.
- Soil, foundation material and construction - must be such that there will not be seepage to the subsurface.
- Retention time – In dry areas it can be as much as 200 days.
- Dam volume - Rule of thumb is 90 days' manure water. The possibility of bad odours and silt accumulation reduces as the volume (capacity) increases, but nitrogen losses however then increase. Nitrogen losses are related to surface area.
- Depth – the dam must be at least 2m deep, but can be as deep as 6m.
- Silt accumulation - Cellulose material such as straw, wood shavings and sawdust that may occur in the manure are not that easily broken down and can cause fast silt build-up, which will have an influence on determining the volume.
- Nitrogen retention - the volume of the manure dam per unit body mass needs to be relatively small.

3.4.2. Pump requirements

For the pumping of irrigation water, conventional pumps are used. The percentage solids will determine whether semi-open, open or closed impeller pumps can be used.

3.4.3. Sieves

The sieve sizes depend on the method of distribution used. For irrigation purposes, the sieve sizes must be smaller than the smallest nozzle. In cases where water is not pumped out of the

bottom of dams, but from the surface, the suction pipe and sieve must float in such a way that the sieve inlet is approximately 450mm below the surface of the water to limit the pumping of solids and vortex formation at the suction pipe inlet.

3.4.4. Irrigation equipment

- If an ordinary sprinkler irrigation system is used it is important to ensure that there are not any solids that can block the nozzles.
- Big gun irrigators and Travelling irrigators are good choices for applying the manure water. They can be fitted with large rubber nozzles (19mm-51mm diameter) that can handle larger solids without blocking.
- Conventional centre pivots. The manure water must be free from solids, to prevent blockages.
- Specially adapted centre pivots fitted with sprinklers with larger nozzles to be able to handle manure water with larger solid particles.
- The minimum size pipe that is suitable for the transportation of the manure water and prevention of blockages is 50mm.
- Aluminium pipes can be vulnerable to chemical reactions with the manure water. However if the irrigation system is flushed with clean water after every application of manure water, no corrosion problems would occur.

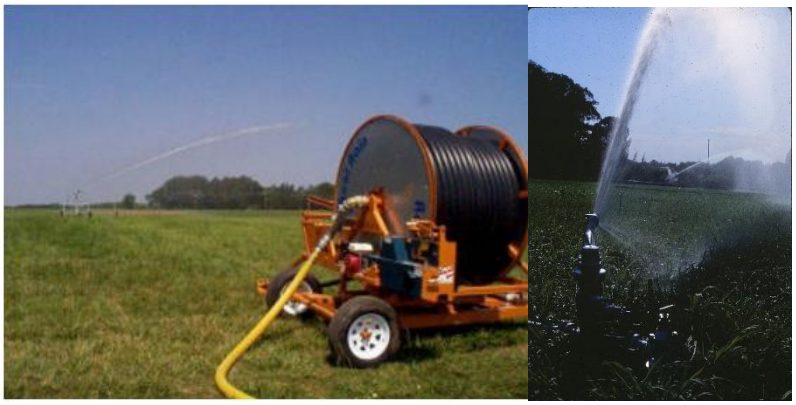

Figure 4: Travelling irrigator applying manure water

4. Small scale operations

In small scale farming operations manure water can also be used for irrigation of crops, with subsequent saving in fertilizer costs. It is applicable to intensive as well as extensive animal husbandry practices.

In short it entails that solid manure is collected and placed in a hessian bag or similar perforated container and soaked in a container filled with water for 3 to 7 days. This brew is then diluted with water and can be applied weekly to the crops through the irrigation system or by hand. The used manure can be composted.

The manure water brew could be analyzed to obtain certainty about the nutrient content, and to enable the farmer to apply supplementary fertilizer to alleviate possible nutrient shortages.

5. Conclusion

In intensive animal farming operations there exists the potential for animal manure water to supplement and in some cases, even replace the inputs of commercial fertilisers. In order to derive the full benefit of animal manure water, while ensuring no environmental pollution, it is very important that the whole system, which includes storage, treatment and disposal, is designed properly and managed effectively.

6. References

1. Smal S. “Irrigation with Animal Manure Water” ARC-IAE June 2004

2. Breedt H. “Mishanteringshandleiding vir intensiewe Diereproduksie-eenhede in SA” ARC-IAE 2008