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CUVEwaters integrated water resources management

CuveWaters Construction Manual # 5

Drip Irrigation

Documentation and Work Instructions for Participants

of Training on Rainwater Harvesting Construction

SPONSORED BY THE

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All publications of this series:

Water Storage:

#1 Ferrocement Tank

#2 Rectangular Underground Tank

#3 Pond

Horticulture and related Infrastructure

#4 Greenhouse

#5 Drip Irrigation

#6 Sustainable Techniques and Practices for Water Harvesting and Conservation and their Effective Application in Resource Poor Agricultural Production (copy provided by the Water Research Commission South Africa)

Preface

„CuveWaters – Integrated Water Resources Management in central-northern Namibia" is a joint research project of German and Namibian partners funded by the German Federal Ministry of Education and Research (BMBF). Main research partners are the Institute for Social-Ecological Research (Frankfurt, Germany) and the Technische Universität Darmstadt (Darmstadt, Germany). Partners in Namibia are for example the Ministry of Agriculture, Water and Forestry (MAWF) and the Desert Research Foundation of Namibia (DRFN), the project furthermore closely cooperates with One World Consultants (OWC) from Kenya. CuveWaters has developed different technologies for water supply and sanitation in central-northern Namibia, ranging from Groundwater Desalination to Rain- and Floodwater Harvesting as well as Sanitation and Water-reuse. Between 2009 and 2013 different pilot plants were constructed at different places all over central-northern Namibia.

This Manual was developed as part of the Capacity Development measures within the technology line of rain- and floodwater harvesting. It is intended to guide you through the process of constructing rain- and floodwater harvesting infrastructure in Namibia.

This Manual is part of a series of Rain- and Floodwater Harvesting Manuals for Namibia:

Water Storage:

#1 Ferrocement Tank

#2 Rectangular Underground Tank

#3 Pond

Horticulture and related Infrastructure:

#4 Greenhouse

#5 Drip Irrigation

#6 Sustainable Techniques and Practices for Water Harvesting and Conservation and their Effective Application in Resource Poor Agricultural Production
(copy provided by the Water Research Commission South Africa)

For more information on organisational, institutional and other general aspects of rain- and floodwater harvesting please have a look in the “CuveWaters Rain- and Floodwater Harvesting Toolkit”.

For more information on the CuveWaters project please visit http://www.cuvewaters.net

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Technische Universität Darmstadt

Darmstadt, 02.03.2015

About

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CuveWaters – Integrated Water Resources Management in Namibia

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This manual is also available on http://www.cuvewaters.net/Publications

For more information on Rainwater Harvesting in Namibia please contact

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1 Preliminary considerations

Before beginning with the construction of a drip irrigation system, preliminary considerations and work instructions should be read carefully. Indication of days means working days of 8 hours, although this may vary from one day to another. The labor needed for the installation process as described is at least 2 people.

The construction manual describes how to build install a drip irrigation system to a greenhouse as conducted during the CuveWaters project for development and implementation of rainwater harvesting as a part of an Integrated Water Resources Management (IWRM) system. In general, a drip irrigation system can also be operated with piped water supply.

1.1 Materials & Tools Preparation

Ideally, most materials (see bill of materials) should be purchased and brought on site before start of construction or at least until needed at construction site. Storage facilities for materials and tools should be provided at or close to construction site. The materials should be stored secure against weather conditions (e.g. rain, wind, and extreme heat) and theft. Tools needed for construction of the underground tank should be available for the period of construction.

Material supply

While tools, tanks and poles for the implementation of drip irrigation can be obtained from most hardware shops in Namibia, drip irrigation equipment can only be ordered from selected specialized shops located in Windhoek, Okahandja and Epalela (Olushandja Dam).

We recommend to order drip irrigation equipment from Aqualand, located with its headquarter in Okahandja: http://www.aqualand.com.na

Aqualand also runs a smaller shop in Epalela close to the Olushandja Dam (between Outapi and Ruacana). For receiving materials from Epalela it is advisable to contact the headquarter in Okahandja first and make sure that the materials are also available in Epalela.

Another possibility to buy drip irrigation equipment is the company Sinclair in Windhoek: www.sinclair.com.na

Please keep in mind that prices can differ in the different shops and seasonal variations are also common. So plan your construction site and the material supply well in advance and compare the prices in the different shops. Most hardware shops offer delivery of the materials for reasonable fees.

1.2 Siting recommendations

Drip irrigation is an improvement for horticulture and can be implemented to already existing beds for horticulture or if new horticulture plots are implemented.

Within the CuveWaters project drip irrigation was part of an IWRM and therefore the drip irrigation was installed to greenhouses as well as on open field. When combining rain and/or flood water harvesting with storage in tanks or ponds and with horticulture with drip irrigation systems it is reasonable to place pond/tank, small-scale water storage and area for horticulture close to each other. When planning and implementing a drip irrigation system please have in mind the space that is required for the raised tank, the pump and filter and drip line connections.

1.3 Drip irrigation components, sizes and dimensions.

This manual describes how to construct and install a drip irrigation system for horticulture in a greenhouse or on open field. The main components of such a system are:

- a small and raised water storage tank, which contains enough water to feed the drip system with enough water for a day
- a pump (manual, electrical or diesel powered), that allows pumping water from a bigger water reservoir to the small raised tank.
- a sand / screen filter that ensures water is not carrying sand and debris which would result in clogging of the drip holes.
- main feeder lines for drainage of water from the small-scale tank to the drip lines
- submain lines for drainage of water and finally connection of drip lines.
- drip lines, which contain the drip holes and fulfill the task of plant irrigation.
- junctions, joints and valves to connect different components and allow for turning off of certain irrigation areas and lines.
- a water gauge to monitor the water distribution from the tank to the irrigation area.

There are different types of drip lines available on the market, which differ in water flow rates (liters/hour) and types of drippers. Within the CuveWaters project drip lines were used, which have a flow rate of 4 liters/hour and internal drippers.

The small and raised water tank is a 1000 l tank made of polyethylene. Depending on the size of the area which should be irrigated with the drip irrigation system and on the water demand of the plants which should be grown, the tank may be larger or the system could be fed by two tanks of this size. Furthermore, the tank has to be in a raised position, so water drainage takes place automatically due to gravity.

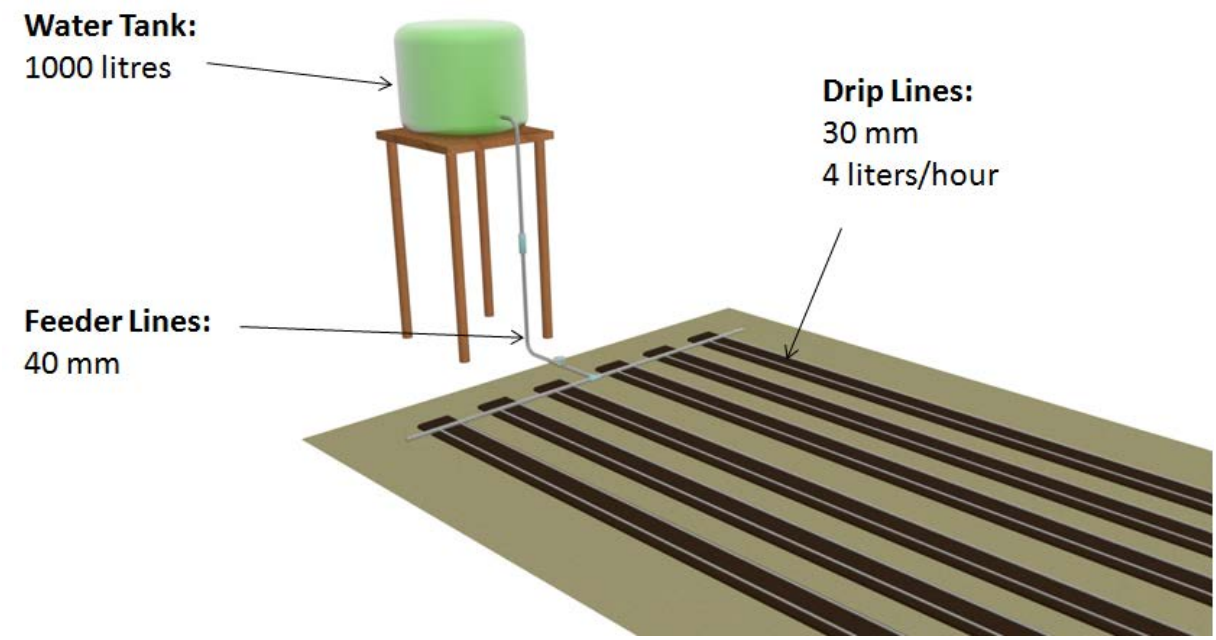

Figure 1: Illustration of drip irrigation system and of main parts.

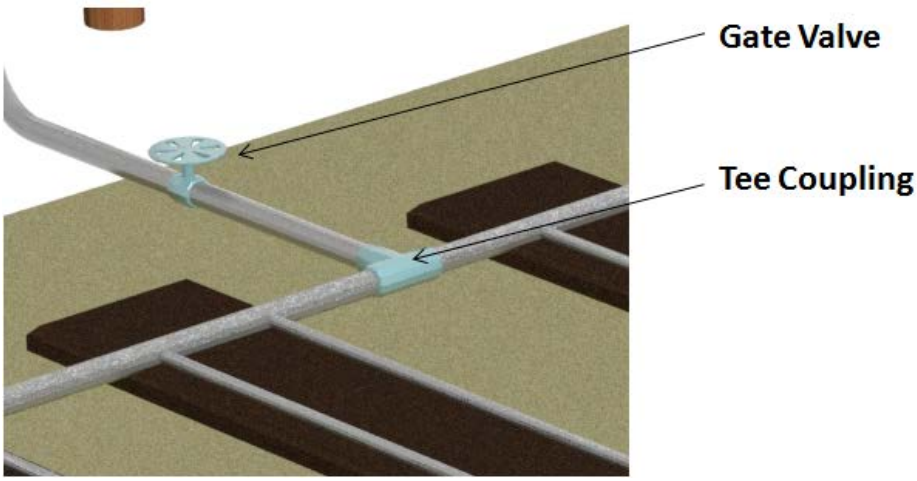

Figure 2: Illustration of drip irrigation components.

The boundary conditions that are used for this description is small-scale gardening on household level. It is assumed to have 6 beds of 15 m length each, which contain two rows of plants and therefore two rows of drip lines. The total area consequently is about 6m x 15 m. The distance between the tank and the beds is assumed to be 5 m. For different garden sizes, quantities for material will differ.

2 General Work Instructions

In the following chapter, activities which are to be done during the process of implementation of drip irrigation system will be described. These actions will be required in the detailed work instructions and therefore should be known.

In general, drip irrigation systems support horticulture activities, which are described in more details in publication #6 of this CuveWater Manual publication series. Drip irrigations systems differ from one producer to another and can be divided into surface and subsurface systems. Within the CuveWaters approach, surface drip irrigation systems were used since they are easy to implement as well as easy to align to the users needs. To reduce investment cost to a minimum, not all components have to be purchased from the producer of drip irrigation lines, but system was set up from special equipment of drip irrigation system manufacturers and standard components for water installations and irrigation.

2.1 How to install threaded connectors

The drip irrigation system contains different types of connectors. Threaded connectors are used especially, to connect plastic and galvanized steel components such as gate valves, reducing sockets, and elbows amongst others. To ensure the connections are water tight for as long as possible, PTFE (polytetrafluoroethylene, or Teflon) tape has to be applied to the male thread before male and female connectors are fastened.

2.2 How to connect feeder / submain lines and nylon connectors.

An easy and cost efficient way to join drip lines (for example made of low density polyethylene – LDPE) to nylon connectors is the usage of hose clamps. Those clamps are available in many sizes and can be fastened with a screw driver to ensure proper and tight connection of components.

A more cost efficient way is the use of binding wire. The wire should be rolled around the LDPE line twice and tightened with pliers. Any case it should be checked if all connections of this type are water tight, when system is put into operation. Leaky connections would lead to spill of water and therefore reduce the yield.

Figure 3 (left): Threaded connection, sealed with PTFE tape.

Figure 4 (rigth): Connection of feeder pipe and nylon elbow with hose clamps.

Figure 5 (left): Connecting LDPE pipe to nylon coupling and gate valve using binding wire.

Figure 6 (right): Connecting LDPE pipe to nylon tee using binding wire.

2.3 How to connect submain lines and drip lines.

Submain lines and drip lines are connected with saddle and nut combination. First mark submain lines where drip lines shall be connected for irrigation of beds. Most reasonable is a two-rowed bed which requires two drip lines per bed. Depending on plants to be grown this may vary.

When submain lines are marked, use a tool to drill, punch or pierce a hole into the LDPE submain line. Suitable tools such as drill bits, punchers and awls which should be used, to avoid leakage of the connections and reduction of lifetime of the system. After submain lines are perforated, the saddles have to be pushed into the holes. Place the nut on the drip line and plug the drip line to the saddles. Fasten the nut to the thread of the saddle to ensure drip line connection is water tight.

Figure 7: Saddle and nut connection for fixation of drip lines to submain lines.

2.4 How to position and connect the water tank.

As already described, the drip irrigation systems uses gravity for drainage of water from the raised tank to the plants on the ground. For this reason, the tank should be positioned on a wooden structure or any other facility suitable. The water tank should have two connections. The upper one is the water inlet of the tank and connected to a pump and the water reservoir. The lower one is the outlet to the feeder and drip lines.

2.5 How to finalize drip and submain lines.

All water lines have to be close at the open end, where garden or bed ends. Finalization is can be done with clamps or binding wire. Drip lines have to be folded about 180° at the end and secured in this position. The kink itself is sealing the drip line from water leakage. The clamp and binding wire secure the line in this sealed condition.

Figure 8: Water Tank of drip irrigation system with inlet and outlet.

Figure 9: Drip line finalized with bend and secured with clamp.

3 Detailed Work Instructions – Construction Diary

The work instructions for the implementation of a drip irrigation system imply, that beds for horticulture are already prepared and other infrastructure of a rain water harvesting system, such as catchment and water reservoir, are constructed or at least planned to be constructed. As already mentioned any other water sources which reliably provide water in appropriate quality can be used.

Depending on manpower, experience, and weather conditions the overall construction time may be longer than this. Sequence may be changed depending on availability of manpower, materials and tools as well as for weather conditions or other reasons. Some of the steps should be done parallel to work most efficiently. Ensure that all material and tools needed for construction are available at the time they are needed. Usually, 2-4 workers are sufficient to install the drip irrigation system.

3.1 Day 1: Siting, and Preparation

On the first day siting and preparation activities have to be done. Check the sites and accessibility of related infrastructures, such as water reservoir and greenhouse or gardens, and check if installation plans of already existing infrastructure match with the on-site situation. Furthermore, it has to be checked where components of the drip irrigation system can be positioned, to allow correct functioning of the system as well as easy operation and service.

Work instructions:

- Inspect the sites and accessibility of water reservoirs, gardens, greenhouse, etc.
- Choose a site for the raised tank and the pump according to the considerations in chapter 1.2 and chapter 1.3.
- Choose how to install feeder lines, submain lines and drip lines and where to put components like water gauge, gate valves and screen filter.
- If there is no infrastructure available where the tank can be lifted up to, mark the site, where wooden structure will be constructed. Mark an area of 1.2 m x 1.2 m with pegs and cord. Dig holes of 50-80 cm depth and a diameter suitable for wooden poles of 100 mm in each of the corners of the square marked with cord.
- Place wooden poles of 100 mm diameter and 3 m length into the holes. Mark poles in a height of 2 m above the ground and cut them to this length. Secure them by closing the holes with soil.
- Cut wooden poles of 100 mm diameter to pieces of 1.2 m length. 4 pieces are needed.

- Fix 2 of the pieces of 1.2 m length at around 1.2 m height above the ground surface in a vertical position between the vertical posts. This will ensure stability of the construction. The other 2 pieces of wood have to be nailed on top of the vertical to connect the posts which are not connected at 1.2 m height yet.
- Cut wooden poles of 75 mm diameter to pieces of 1.2 m length and fix them horizontally on top of the wooden structure to form a platform. 16 pieces should be position next to each other to form a platform of 1.2 m x 1.2 m.

Figure 10: Wooden structure to carry the raised water tank.

- Finally, place tank on top of the platform and tighten it to the platform. Tightening should be done with straps of binding wire which run from the top of the tank to the platform (this is the recommended option). Second option is to nail pieces of timber around the tank to ensure lateral movement to any side is not possible. Nevertheless, strong wind could cause overthrow the tank if not tied properly.
- If components of the irrigation system such as pump, tank and beds for gardening are not in close proximity, it may be helpful to bury water lines from reservoir to pump and from pump to tank into the ground. Maybe burying the feeder lines as wells is reasonable when lines are quite long. If lines shall be buried, make trenches where they shall be installed.

3.2 Day 2: Installation of feeder and submain lines.

On the second day the feeder and submain pipes will be installed. Start placing feeder and submain lines on the ground or in the trenches made for subsurface installation. At each position where a connection to any other component has to be installed, leave the lines longer. This will ensure that all connections can be executed in the best way possible later on. When feeder and submain lines are in position, all connections can be executed beginning from the tank.

The amount of work is highly dependent on the overall complexity of the irrigation system. The described system is an easy configuration with only one feeder pipe and two submain pipes. Nevertheless, all activities and components can be adjusted to build a more complex system with possibility to control water flows more precise and manage water supply from two or more reservoirs.

Ensure that connections are executed properly as described in chapters 2.1 and 2.2.

Work instructions:

- First install a ball valve to the tank outlet to ensure that shut off of the water supply is possible in case of leakage within the drip irrigation system. A valve with a single handle allows for easy verification whether valve is in opened or closed position. Valves are usually made of galvanized metal and equipped with threads for connection to pipes or other components.
- Next component in line should be the screen filter. It is necessary to clean the water from sand and debris which would clog the drip emitters in the drip lines. It is possible to have a piece of feeder line between the valve and the filter and position the filter at a height that allows a more easy inspection and service.
- After the screen filter a water gauge should be installed. The gauge is a helpful tool to observe the amount of water distributed from the tank to the plants. The gauge should be positioned in a way to allow easy reading. Installation of water gauges may be possible in a certain direction only. Please have a look to the data sheet of the specific component used.


Figure 11 (left): Ball valve and screen filter connected to small-scale water tank.

Figure 12 (right): Installation of water gauge.

- When two gardening areas in different directions are to be irrigated with the drip irrigation system, the feeder line has to be divided into two submain lines in the next step. For this reason plug a tee connector into the feeder line and the submain lines on the other end. Fix the tee connector using a hose clamp or binding wire.

  This split from feeder to submain lines can either be done in vertical position (e.g. fixed to the wall or a post of the facility to carry the tank) or in horizontal position on the ground.


Figure 13 (left): Tee connector to split feeder line into submain lines (on the ground)

Figure 14 (right): Tee connector to split feeder line into submain lines (wall installation)

- For better regulation of water provision to the garden area, install another ball or gate valve for each of the submain lines.
- Then start marking the position where drip lines will be connected to submain lines.
- Begin with connection of drip lines to the sublines as describes in chapter 2.3. It is very important, that installation of saddle and fixation of drip line are done immediately one after another!

Otherwise sand and dust could enter the lines and clog drip emitters. Each of the drip lines connected to the submain lines has to be finalized as describes in chapter 2.5.

3.3 Day 3: Completing the connection of drip lines and initial operation.

On the third day of installation, the drip lines will be connected to the submain lines and finalized. When the system is ready, the raised tank will be connected to the pump or other water supply. Finally, the commissioning with a visual leak test will be done.

Work instructions:

- Complete the connection of drip lines and submain lines as well as the finalization of the drip lines.
- When all components are connected and no open water lines do exist close all ball and gate valves.
- Then connect the raised water tank to the pump or water supply and fill it with water. Approximately one fifth of the tank volume should be filled in for the commissioning. While filling water into the tank, check if connection of tank outlet and feeder line and/or ball valve is water tight.

  If leakage is visible, stop filling water into the tank. Open the connections with caution and empty the tank. Rework the leaky connection to ensure water tightness.
- When connection of feeder line and ball valve to tank outlet is water tight and tank is filled with a sufficient amount of water, open the ball valve. You should be able to recognize water running through the valve and streaming into the water line behind it. Check all components and connections from the first valve to the following valves for water tightness.

  If a leakage is visible, close the ball valve next to the outlet of the tank. Then, rework the leaky connection to ensure water tightness. If the leaky connection has to be reworked, open it with caution and empty the water line next to it.
- When all connections and components between the first and the second valves are water tight, open the gate or balls valves and check if all connections from submain to drip lines are water tight. Check if the finalizations of the drip and submain lines are tight as well.

  If a leak is visible, close the ball valve next to the leaky connection or component. Then, rework the leaky connection to ensure water tightness.

- When the whole drip irrigation system was checked and found to be water tight, the system is ready for use and daily operation.

- If feeder and/or submain lines were installed to trenches, close these with soil.

Figure 15: Implemented drip irrigation system with water tank and drip lines for gardening in the open.

Your drip irrigation system is ready!

4 Estimated Bill of Material

	Material	Quantity	Approximate Amount in N$
1	Water Line LDPE 40mm	10 m	100
2	Pipe LDPE 32mm	10m	100
3	Drip Line 4l/h x 30mm	200 m	800
4	Drip Saddle and Nuts	15	45
5	Valve Ball Lever 40mm Full Bore Agri-Lock	1	110
6	Water Tank Polyethylene 1000l	1	1600
7	Gate Valve Brass 32mm	2	160
8	Screen Filter	1	
9	Water Gauge	1	
10	Nylon Tee 40mm	1	10
11	Pipe Clip UPVC 40mm	4	40
12	Galv. Reducing Socket 20 x 15mm	2	15
13	Galv. Reducing Socket 40 x 20mm	2	30
14	Nylon Adaptor Male 40mm	4	7
15	Nylon Elbow 40mm	2	15
16	Nylon Adaptor Male 32mm	4	14
17	Nylon Coupling Reduce 40/32mm	2	12
18	Tape PTFE Each Loose	10	27
19	Hose Clamps 32 x 57mm	10	60
20	Hose Clamps 19 x 44mm	6	66
21	Binding Wire 1.6mm x 100m	1	40
22	Wooden Support Poles 100mm, 3m	6	550
23	Wooden Support Poles 50mm, 2.4m	8	320
24	Wire Nails 120mm x 5mm 1kg	3	60
	Total Materials		**4181**
26	Proposed labor (man days)	6	600
	Grand Total		**4781**

Material needed for drainage system to the tank and/or pond is not included in this bill of material. Quantities differ if size of area to be irrigated differs and/or installation requires more bends or a more complex configuration of drip irrigation system.

5 Bill of Tools

	Tools	Quantity	Approximate Amount in N$
1	Spade	1	105
2	Saw Hacksaw Frame	1	45
3	Hammer Claw 500gr	1	170
4	Spirit Level, Aluminum 600mm	1	80
5	Plier, combination	1	50
6	Bit HSS 9.5mm	1	20
7	Bit HSS 7mm	1	20
8	Screwdriver 6x100mm	1	18
9	Puncher or Drill Bit	1	100
10	Tape Measure 5m x 25mm	2	80
	Grand Total		**688**

Amount of tools is sufficient for 2 workers.

6 Construction Procedure Table

Day of preparation and days for curing of concrete and mortar were not counted in the detailed work instruction, but are counted in the table below.

Day	Activity	Materials used	Remarks
Day 1	Purchase and supply of materials.		
Day 2	Siting and Preparation	Wooden support poles Binding wire Nails Polyethylene tank	
Day 3	Installation of feeder and submain lines	LDPE Lines 40mm and 32mm Ball valve 40mm and gate valves 32mm Water gauge Screen filter PTFE tape Connectors, reducing adaptors etc Hose clamps Drip Lines Saddles and Nuts	Puncher or drill bit needed
Day 4	Completing the connection of drip lines and initial operation	Drip Lines Saddles and Nuts Binding wire	Puncher or drill bit needed

7 Maintenance of the Drip Irrigation System

Maintenance of the drip irrigation systems is essential for correct functioning of the system. In general, visual inspections should be done weekly to realize malfunction or leakages immediately. Furthermore, the screen filter needs service on a regular basis.

7.1 Visual inspections

Once a week the connection of the drip irrigation system should be visually inspected regarding tightness. Especially, the connections with saddle and nut of drip lines and LDPE lines of bigger diameter should be checked regularly. If leakages are obvious, the repair should be done as soon as possible to avoid spill of water.

7.2 Cleaning the screen filter

Screen filters have to be cleaned on regular basis. Please have a look at the data sheet of the manufacturer which intervals should be used for screen filter service. For cleaning the filter, shut off the ball valve and wait for a few minutes to allow water drain the feeder line. Then, screw off the housing of the filter and remove the insert and clean it from sand and debris with water. When the filter insert is cleaned, put it back in position and close the housing of the filter. Open the ball valve to allow regular operation of the system.

7.3 Repair of leakages

Leakages may occur due to several reasons. Small leakages which were present from the beginning may grow or mechanical stress may damage connections of water lines and other components. In any case, a tight system should be restored either by rework of connection or by replacement of lines or components.

Figure 16: Connection cracked due to too high mechanical stress.