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Environmental evaluation of subsurface drainage system in a coastal region of Iran

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Introduction

- ◆ **Subsurface drainage is essential for water management and improved productivity of agricultural lands in humid regions with slowly permeable soils.**
- ◆ **Aside from economic considerations, it is necessary to consider environmental aspects in sustainable agriculture.**
- ◆ **Flow of drainage water is known to increase the quantity of outflow and to contain soluble nutrients and salts that can negatively impact the receiving water body.**

Introduction

- ◆ **Nearly 50 percents of United States wetlands have been transformed to agriculture fields through installation of drainage systems. This transformation has caused the immigration of different kinds of birds and increased their population in other wetlands.**
- ◆ **Drying of Aral lake is just another catastrophic example that has happened by the development of irrigation projects.**
- ◆ **The environment of wetlands is crucial for the survival of plants and wildlife. Their role is very important for tourism industry.**

Objective of this study

- ◆ **The Miankale bay is a biosphere reserve and is especially important with regard to environmental problems and also is an outlet of drainage system in a region in northern part of Iran.**
- ◆ **The objective of this paper is to evaluate the performance of drainage system on Miankale bay with respect to its environmental impacts.**



Description of the site

The Miankale bay

Semi-Mediterranean climate

Average annual rainfall = 577 mm

Average annual temperature = 16 °C



Importance of drainage in this case study

- ◆ Installation of drainage system was necessary in the area due to:
 - **High water table**
(with an average depth of 0.5 m)
 - **High salinity of groundwater**
(EC = 55- 129 dS/m)
 - **High salinity of soil**
(more than 80 percents of fields had a very high salinity and alkalinity)

The drainage system

- ◆ To prevent water logging and soil salinization 125 mm diameter drains were laid at a depth of 1.5 m. Corrugated perforated PVC pipes with rice husk envelope were spaced at 75 m with 440 m length.
- ◆ The drainage system consists of open earth collector drains with an outlet to Miankale bay. Drainage water was from excessive rain, as the field was under dry farming and was not being irrigated.



The Miankale bay

- ◆ The Miankale wildlife conservation area is recognized internationally by the United Nations on 17 Jan, 1977 for the protection of environment by division of "mankind and environment".
- ◆ The Miankale wetland is permanent and a suitable environment for native birds as pheasants and francolin. This wetland also is suitable refuge for peregrine birds like black stork, grey goose, partridge, and different kinds of duck that travel from Siberia to this Torrid Zone in winter season.



The experimental field and data measurements

- ◆ The study area was located between two subsurface drains designated as S3PD14 and S3PD15.
- ◆ Subsurface drainage system was monitored in rainfall seasons in 2006 and 2007. Parameters such as drainage discharge rate and quality of soil and drainage water were recorded.
- ◆ Changes in soil quality were monitored by collecting soil samples at 0–25, 25-50, 50-75, 75-100 and 100-150 cm depths at the midpoint between two drains before and after the rainfall seasons.
- ◆ In this study, quality of drainage water and sediments collected from drain pipes were analyzed by measuring electrical conductivity (EC), sodium adsorption ratio (SAR) and cations' concentrations (Na, Ca + Mg).

A high-speed photograph of a single water droplet falling into a pool of water. The droplet is captured mid-fall, just above the surface, creating a small splash and a series of concentric ripples that spread outwards. The water is a clear, light blue color, and the background is a plain, light blue gradient.

Results and discussion

Soil water quality

☛ Chemical characteristics of soil layers before rainfall seasons (August, 2006)

Depth (cm)	ECe (dS/m)	pH	Na ⁺ (meq/l)	Ca ⁺⁺ + Mg ⁺⁺ (meq/l)	SAR	ESP
0-25	35.4	7.5	220.0	46.2	45.8	39.8
25-50	49.2	7.1	336.5	67.8	57.8	45.6
50-75	53.5	7.4	337.0	72.7	55.9	44.8
75-100	62.2	7.5	464.3	94.8	67.4	49.5
100-150	75.4	7.3	519.5	105.3	71.6	51.1

Ave.: 55.1

Soil water quality

💧 Chemical characteristics of soil layers after rainfall seasons (April, 2007)

Depth (cm)	ECe (dS/m)	pH	Na ⁺ (meq/l)	Ca ⁺⁺ + Mg ⁺⁺ (meq/l)	SAR	ESP
0-25	8.8	8.2	80.2	10.0	35.9	34.1
25-50	34.9	7.9	286.3	39.1	64.8	48.5
50-75	52.0	7.9	418.9	76.2	67.9	49.7
75-100	49.8	7.8	426.1	64.3	75.1	52.3
100-150	61.4	7.8	433.6	97.2	62.2	47.5

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Soil water quality

- ◆ In fact salinity returns in the coastal boundary fields of Ran because subsurface seepage from the bay to the fields, resulting in a weak performance of drainage system due to lack of salinity control.



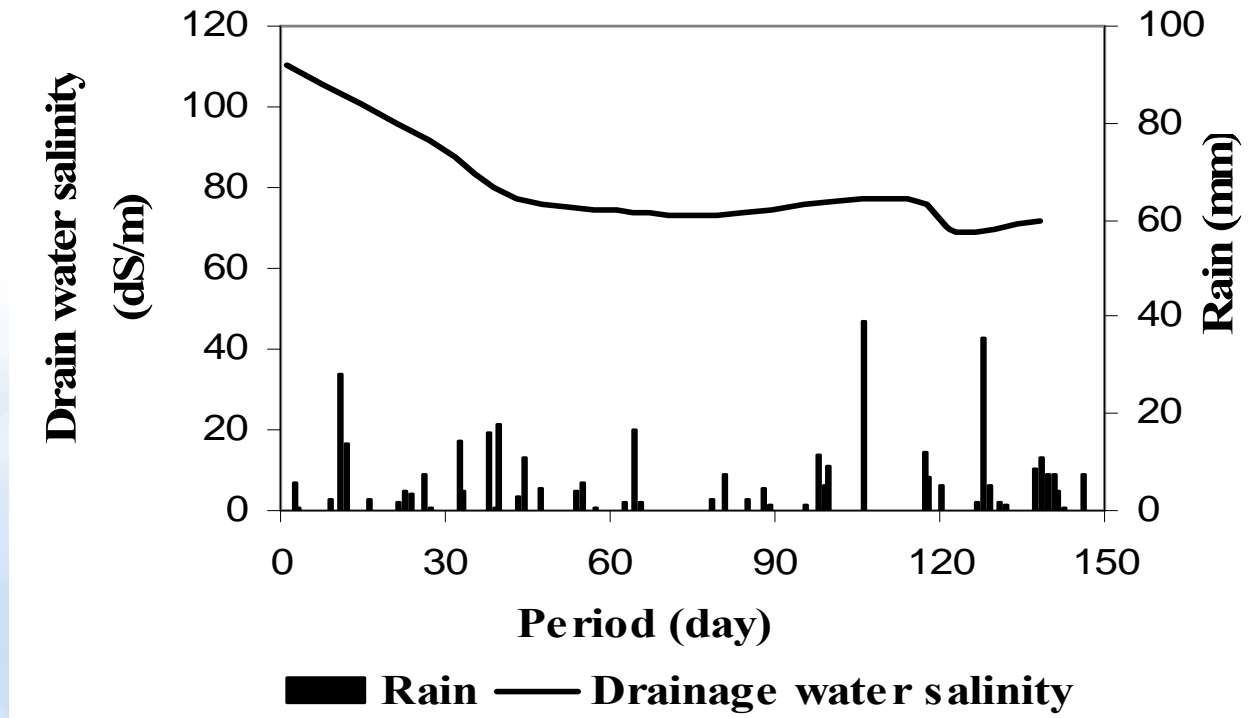
Drainage water quality

💧 Drainage water Quality during the measurements

Sample	Date	EC (dS/m)	pH	Na ⁺ (meq/l)	Ca ⁺⁺ + Mg ⁺⁺ (meq/l)	SAR	ESP
1	2006/11/18	110.7	7.35	880.2	194.1	89.3	56.6
2	2006/12/14	91.5	6.84	811.5	172.5	87.4	56.1
3	2006/12/30	77.2	6.64	783.8	136.7	94.8	58.1
4	2007/01/17	74.3	6.64	731.0	81.6	81.6	54.4
5	2007/01/31	73.1	6.61	635.2	72.7	72.7	51.5
6	2007/03/10	77.6	6.51	642.6	173.9	68.9	50.1
7	2007/03/19	68.9	6.78	629.4	151.1	72.4	51.4
8	2007/04/04	72.0	6.69	553.3	151.1	63.7	48.1

Drainage water quality

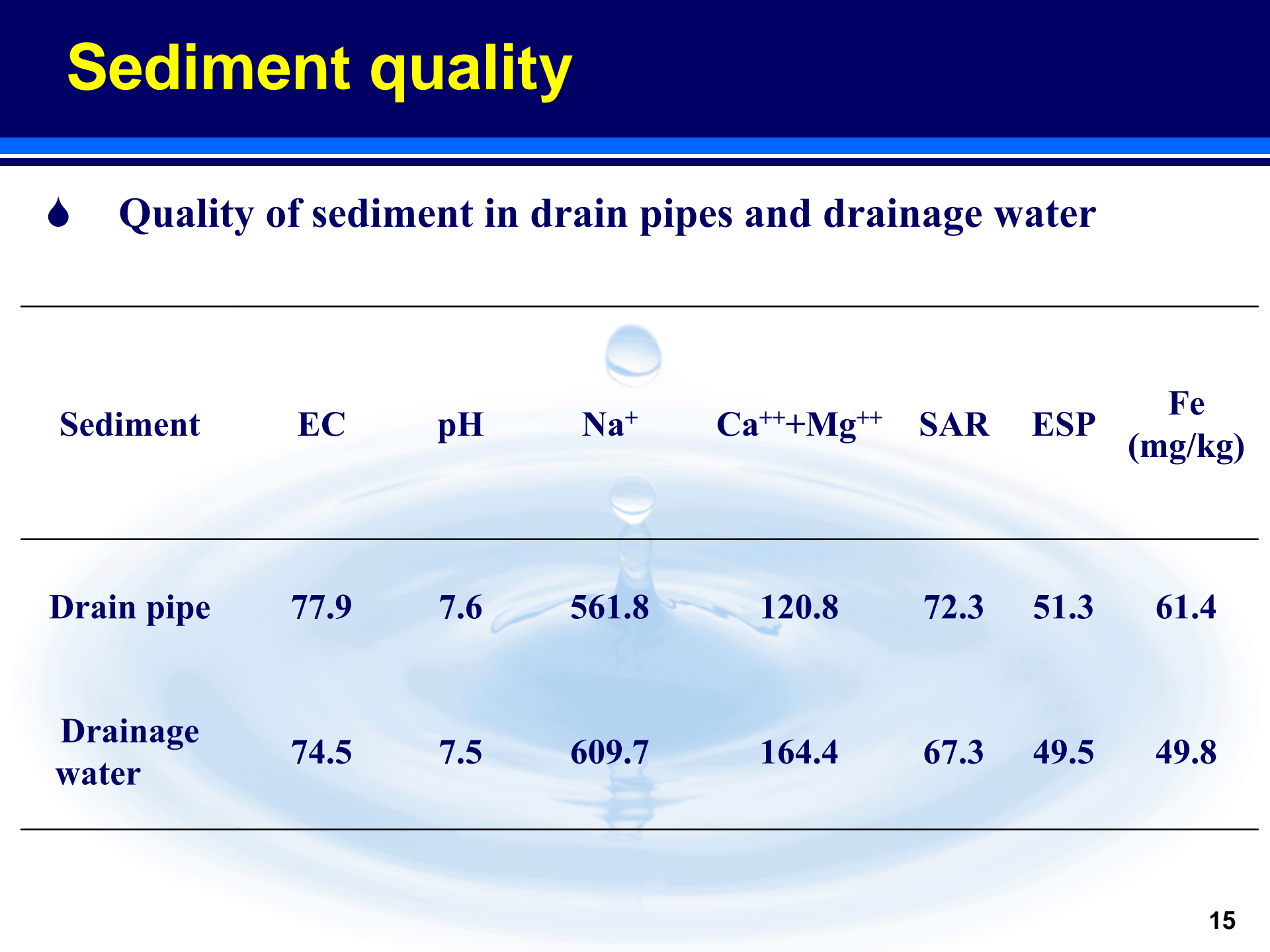
💧 Variation in drainage water salinity with time and rainfall



💧 The bay water salinity changed from 17.2 dS/m to 24.3 dS/m while average salinity of drainage water was measured about 80 dS/m.

Sediment quality

💧 Quality of sediment in drain pipes and drainage water



Sediment	EC	pH	Na ⁺	Ca ⁺⁺ +Mg ⁺⁺	SAR	ESP	Fe (mg/kg)
Drain pipe	77.9	7.6	561.8	120.8	72.3	51.3	61.4
Drainage water	74.5	7.5	609.7	164.4	67.3	49.5	49.8

Estimation of drainage load

💧 Drainage load-flow linear relationships ($y=ax$)

	a (kg/m³)	R²
Total salt	66.0	0.77
Na⁺	16.7	0.84
Ca⁺⁺+ Mg⁺⁺	4.9	0.78

Estimation of drainage load

- Monthly loads of total salt, sodium and sum of calcium and magnesium in experimental field during the measurement

Month	Total drainage water volume (m ³)	Load amounts (kg)		
		Total salt	Na ⁺	Ca ⁺⁺ + Mg ⁺⁺
Azar	798.0	52667.1	13326.4	3910.1
Dey	662.6	43730.7	11065.2	3246.7
Bahman	517.8	34177.8	8648.0	2537.4
Esfand	551.7	36414.2	9213.9	2703.5
Total	2530.1	166989.8	42253.5	12397.7

Estimation of drainage load

- It is concluded that load of salts entering Miankale Bay (known as “Paradise of Asian birds”) were very high and would cause dilemma to coastal environment and ecosystem of wild life.

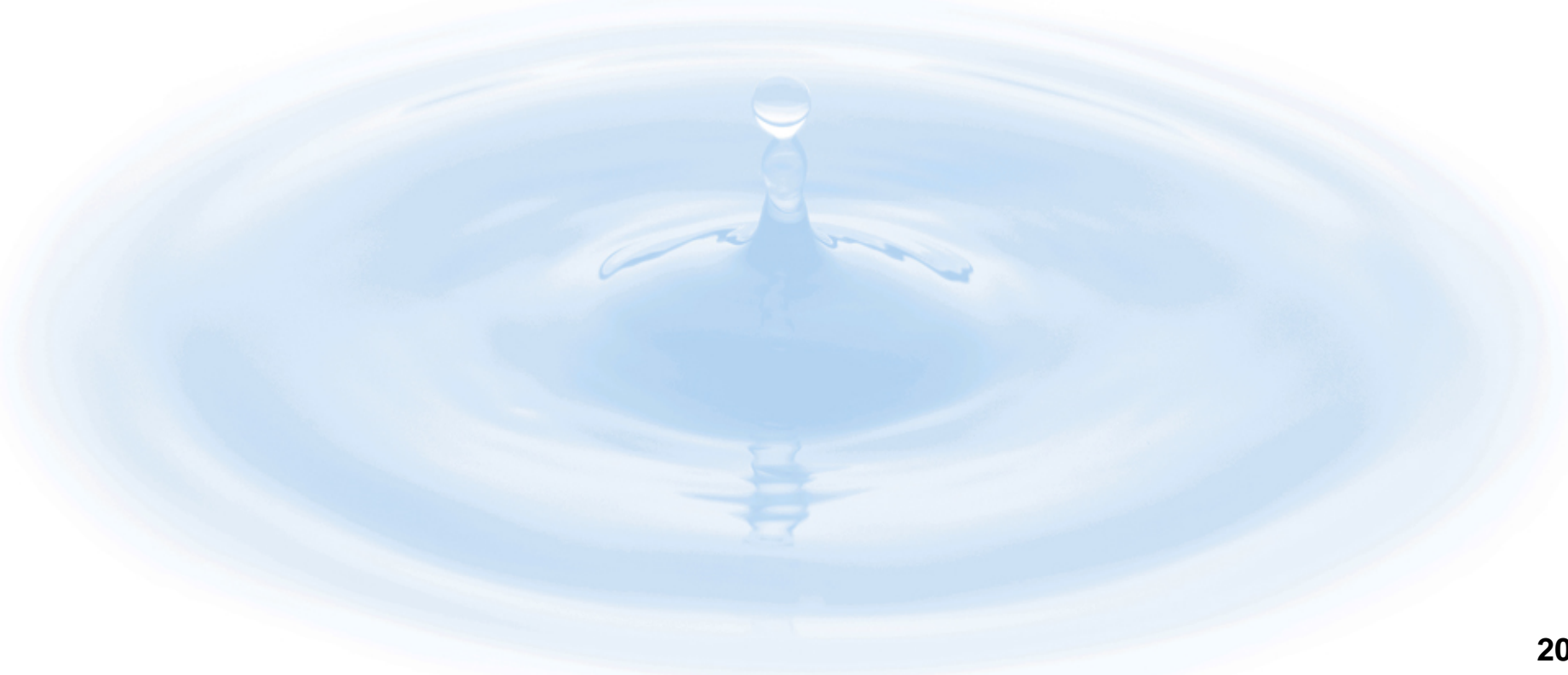


Conclusions

- ◆ **General trend of subsurface drainage system to control water table and soil salinity was found to be insufficient because of the observed subsurface seepage from Miankale bay to the field.**
- ◆ **Entrance of polluted drainage water to Miankale wetlands will cause great losses in future and to the birds' population.**
- ◆ **Elimination of many native birds and aquatic plants and introduction of new species will disrupt ecosystem balance and eliminate local birds and plants.**

Conclusions

- ◆ This study also showed that use of only traditional drainage design equations for protection against water logging and salinization are inadequate for water quality management.

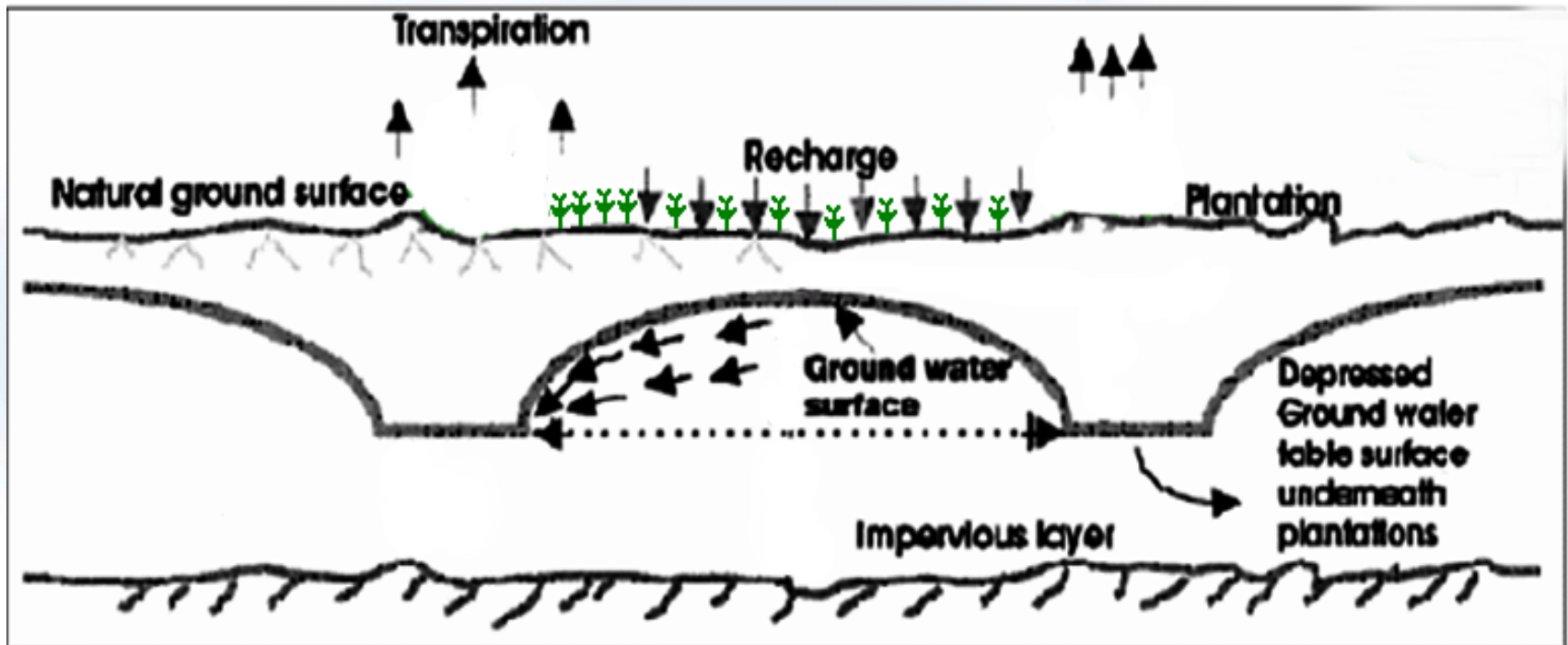


Recommendations

- ◆ **Shallow drains will significantly decrease drainage water salinities as compared to deep drains.**
- ◆ **Reuse of drainage water and plantation of salt tolerance crop (Artiplex and eucalyptos) can reduce volume of drainage water**

Recommendations

- ◆ Drydrainage could also be a viable option in this area; in fact drydrainage is similar to biodrainage other than the fact that drydrainage evolves introduction of fallow lands instead of trees borders.



Recommendations

- Controlled drainage can be considered as an alternative to reduce volume and salinity of drainage water, nitrate and phosphate losses to downstream water bodies and ecological damage.



- A more extensive study on drainage water quality would be recommended for evaluation of drainage system impacts on Miankale environment because Miankale bay is particularly important from the viewpoint of ecosystem.

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**Thank you for your
attention**

