Food and Agriculture Organization of the United Nations

International Union of Soil Sciences

SALTY SOIL ADVENTURES

A collection of ten children's stories from around the world

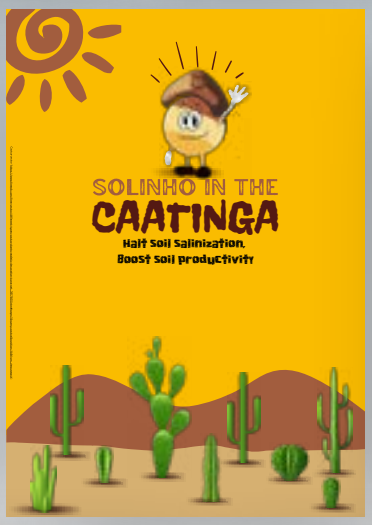
GLOBAL SOIL PARTNERSHIP


The Beetles
Tally Soil Journey


EARTH'S EXTRAORDINARY SOIL FOR ALL LIVING ORGANISMS
Learning, thinking, and acting!


Cookie's Apple Dream
Written by Frederick Asankom Dadzie, Chen Han
Illustrated by Ao Chen
Art designed by Chen Han


Why can't crops be grown in the fields?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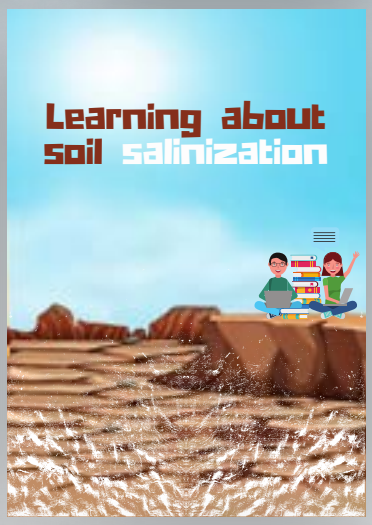
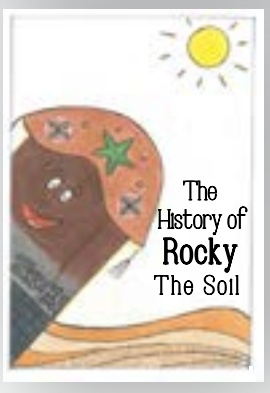
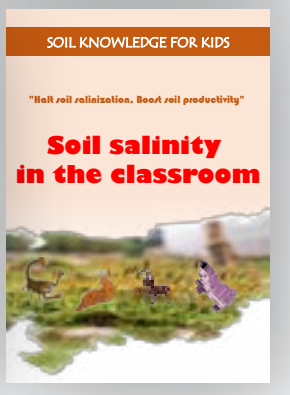
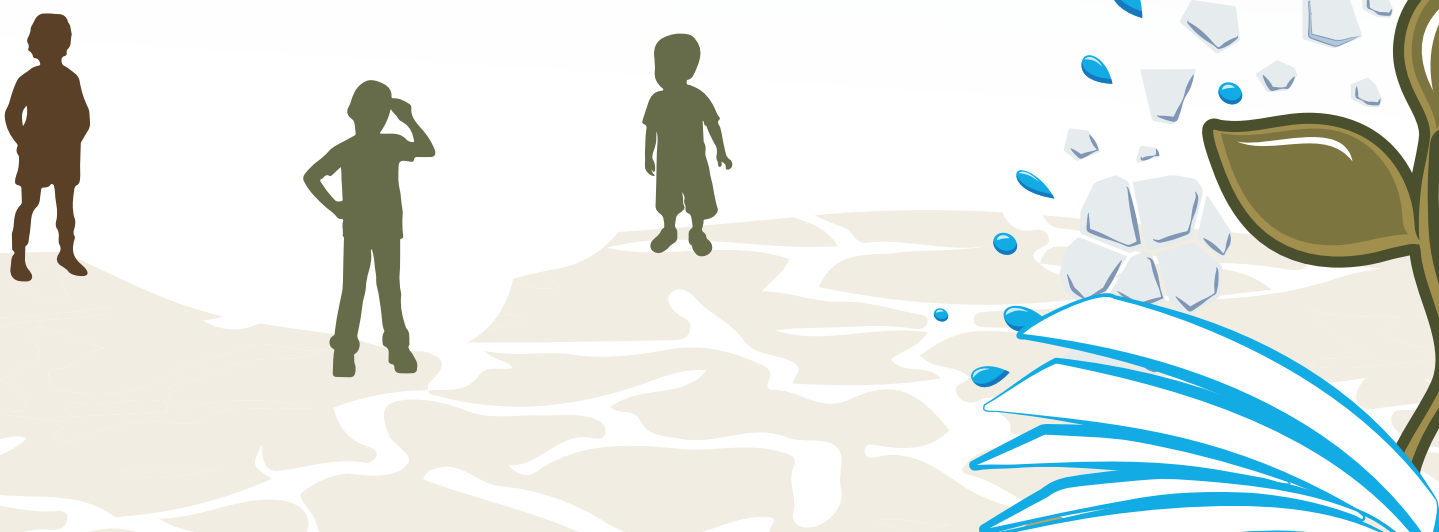
Halt Soil Salinization,
Boost Soil productivity


Learning about
soil salinization


The
History of
Rocky
The Soil


Reversing Salinity, Preserving Soil
Halt soil Salinization,
boost Soil Productivity
BY TIRUNIMA PATLE

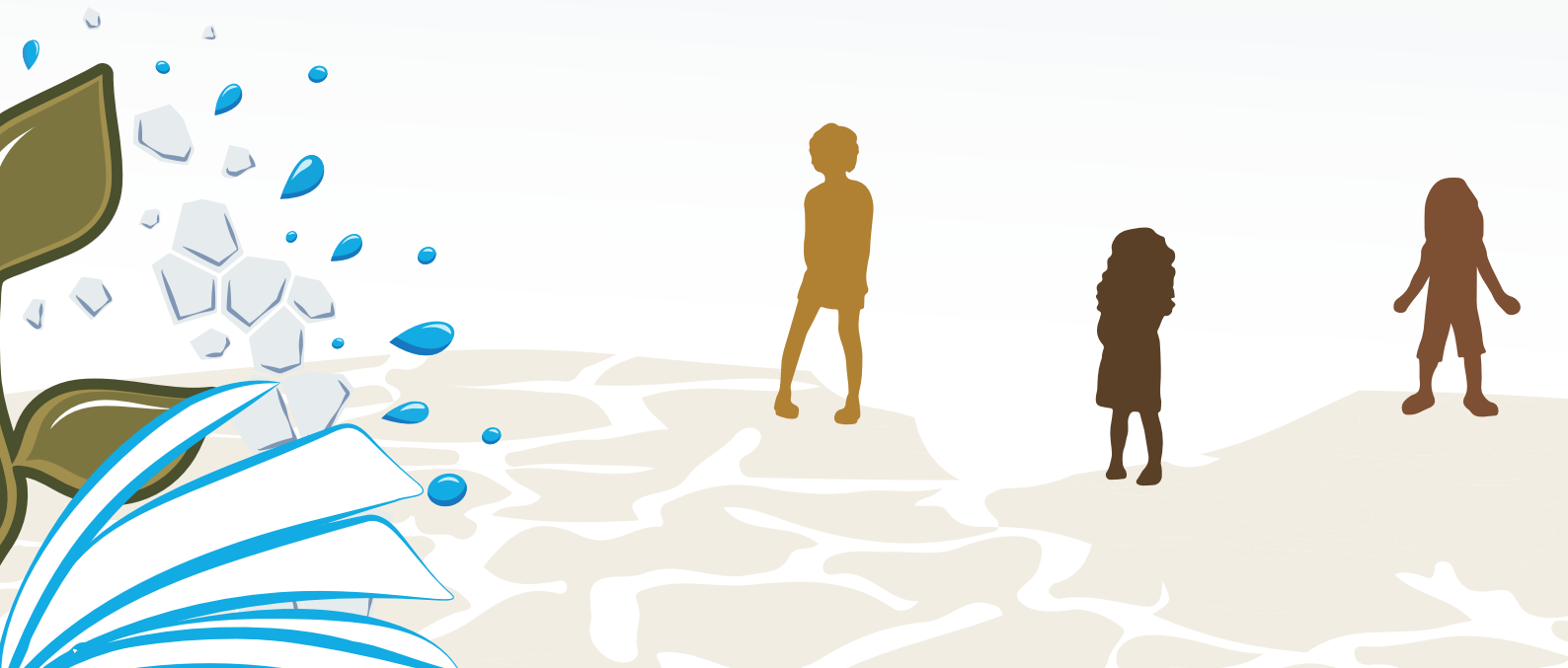

SOIL KNOWLEDGE FOR KIDS
"Halt soil salinization. Boost soil productivity"
Soil salinity
in the classroom



SALTY SOIL ADVENTURES

A collection of ten children's stories from around the world

Food and Agriculture Organization of the United Nations
and
International Union of Soil Sciences
Rome, 2022



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Contents

Foreword

Salts are a natural and free-moving part of soils and water, worldwide. When they increase and build up in the soil, salts can adversely affect most of plants and are then known as saline soils. Naturally saline soils can support wonderfully rich ecosystems, but when improper human activities increase soil salts, the process is called salinization. Soil salinization threatens our soils and reduces their ability to grow our food. This is a major soil degradation process which is harmful to certain ecosystems worldwide , especially in dry climates. It is recognized as one of the most pressing global problems for agricultural production, food security, and sustainability in arid and semi-arid regions.

On 5 December 2021, the eighth UN World Soil Day celebrations focused on the theme "Halt soil salinization, boost soil productivity". It reached over 1.15 billion people worldwide, with a registered amount of 781 events in more than 125 countries. Since its creation in 2014, this annual event has successfully raised awareness of the importance of maintaining healthy ecosystems and human well-being by addressing the growing challenges in soil management and encouraging societies to improve soil health.

In the framework of World Soil Day 2021, the Food and Agriculture Organization of the United Nations (FAO), its Global Soil Partnership (GSP) together with the International Union of Soil Sciences (IUSS) launched a scientific children's booklet contest on salt-affected soils. The booklets, received as part of the contest, illustrate the impacts of salinization and sodification (another type of soil salt problem affecting soil structure) on soils and the consequences for the livelihoods and welfare of the affected populations and ecosystems. They highlight how these processes impact food production and offer practical solutions with information on the sustainable management of salt-affected soils.

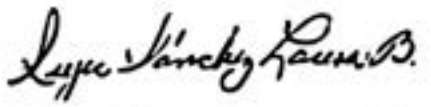
We would like to express our deep appreciation for the quality of the work submitted and the commitment shown by all those who participated in this contest. Soil scientists, researchers, professors, teachers, students, soil practitioners, designers, writers, and photographers from all parts of the world submitted twenty-seven books! Their efforts have been hugely successful at giving visibility to the importance of the fight against soil salinization while raising awareness of the need to protect healthy soils.

This special collection presents a selection of some of the best entries, keeping a balance between the regions that participated in the contest. Each story is told in a funny, beautiful, and unique way, to help children understand the importance of taking care of soil and the reality of salt-affected areas around the world. Our hope is that this special issue will serve as a useful and positive starting point for parents, schools, and educators to talk to their young audience about the urgency of this threat to healthy soils, and most importantly, why all of us should care. We also hope that the children that come across this book will be further inspired to continue learning about soils and their importance and consider pursuing these studies in the future.

We invite all children to explore the various aspects of soils, to understand the danger that salinization poses to our lives, but also to immerse themselves in the amazing richness of saline and sodic ecosystems.

We wish you a lovely reading!

Ronald Vargas
FAO GSP Secretary



Laura Bertha Reyes Sanchez
IUSS president

Acknowledgments

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The Beetles

A Salty Soil Journey

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Lewis Fausak is the Applied Biology Research Technician at the University of British Columbia. He studied the effects of grassland set-asides on greenhouse gas emissions and plant-available nitrogen, earning an M.Sc in Soil Science. He created @adventures_in_soil on Instagram, where he shares soil science illustrations. His images are featured in "Digging into Canadian Soils: An Introduction to Soil Science".


The Beetles
A Salty Sail Journey

"Well, all my bags are packed for my next big adventure to go and see cousin Tiger Beetle," says Beetle.

"Let's see, do I have everything? **Humus*** for a snack on the road - check, '*How to Improve Your Soil*' textbook - check, and my best buddy Mite to accompany me?"

"Bark Bark Bark!" Mite confirms excitedly.

"I am so excited to go see Tiger Beetle and visit somewhere new, nice, and warm!"

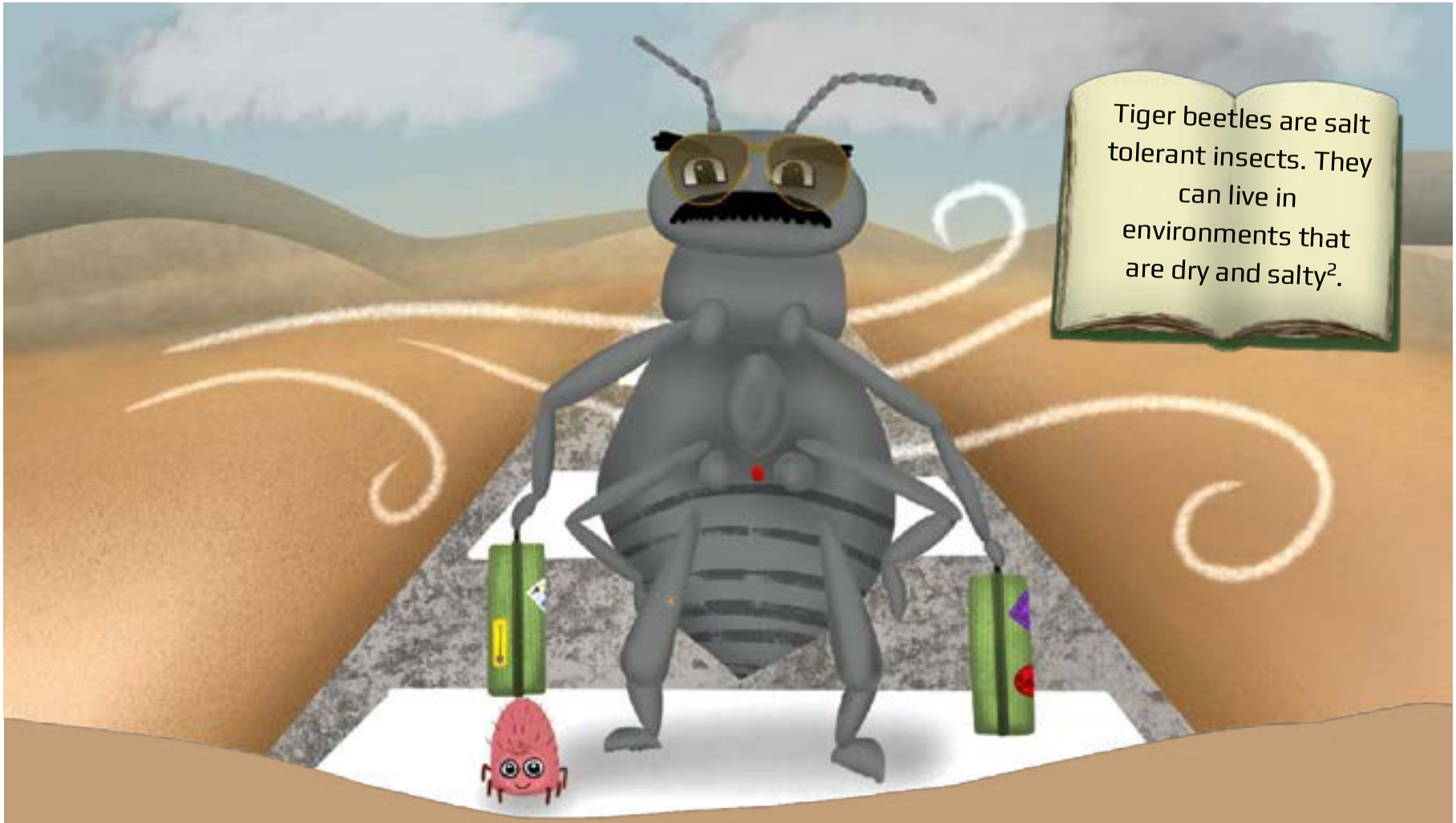
*Learn more about bolded words on page 16

"All aboard the pigeon express flight!" booms Captain Pigeon. "Prepare for take-off."

They continue, "We are expecting a smooth flight today with a few bumps along the way. Your destination is going to be a hot and sunny 35 degrees celsius with frequent wind storms. As you know this area is having issues with soil salinity, and the increasing temperatures are not very helpful. As always, we want you to know you are a valued customer, and thank you for flying Pigeon Express."

"What!?!" cries Beetle "I didn't know Tiger Beetle is having salinity issues!"

Did you know that soil salinization caused by inappropriate irrigation practices affects approximately 60 million ha, or 24% of all irrigated land worldwide[1]?
South Asia, Central Asia, and Africa are the regions most affected by this type of soil degradation[1].



"Cousin!" cries Tiger Beetle, "What a relief to see you!"

"Tiger! It's been too long! I have to say this reunion is not as sweet as I imagined. What's going on here? What is this? I thought you lived in a thriving ecosystem!"

Mite licks a salt flake. Beetle kicks the **salt crust** at the surface of the soil. "There are almost no plants in sight!"

"Indeed, there's a lot to discuss. But we're going to have to take cover, a windstorm is brewing," says Tiger.

Beetle scoops Mite up. The cousins do their best to cover themselves as they are plummeted by salty soil bits.

"What was with that storm?"

"Bark Bark!"

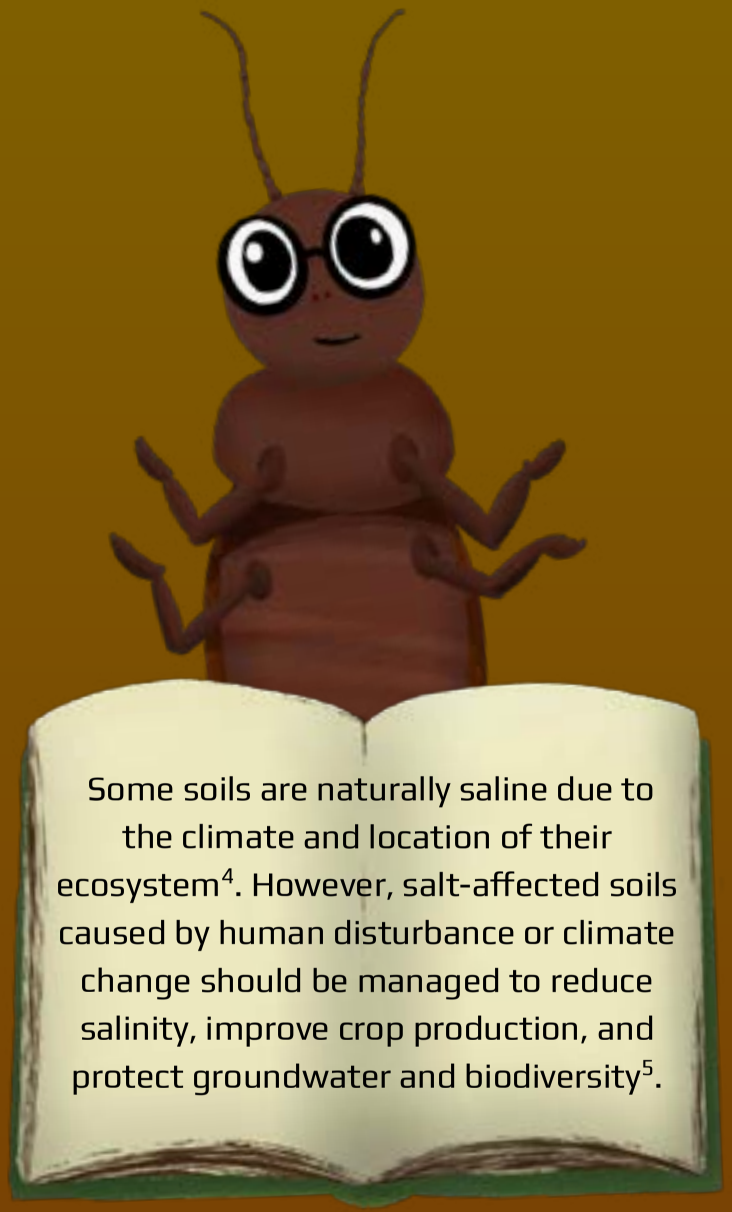
"Oh dear, Mite is thirsty. Would you have a glass of fresh water?" asks Beetle.

"Well cousin, I only have a little left, but even our **groundwater** has become salty."

"Is it that bad?"

"Where do I even begin? There used to be farmers here, growing gorgeous leafy crops. They watered their plants, but the water they used had salts in it. As the water evaporated, too many salts stayed behind, and over the years things started to get bad. Plants don't grow well in salty soil—'**saline** soil' they call it. The plants can't get enough water or nutrients to grow, there's no balance! Personally, I'm okay with the salt, but many of my friends and prey were getting sick and had to go. Eventually the farmers had to move to the city—they couldn't afford to be here anymore. I'm lonely now... so that's why I invited you! "

"Oh Tiger! I'm so sorry you are going through a hard time," says Beetle "I should have come sooner."



Some soils are naturally saline due to the climate and location of their ecosystem[4]. However, salt-affected soils caused by human disturbance or climate change should be managed to reduce salinity, improve crop production, and protect groundwater and biodiversity[5].

"And what about this storm?"

"Well, this salt thing is a problem all over the world. Somewhere not too far away they have a similar situation. The salt they have is called **sodium**, and their soil is '**sodic**'. It makes the **soil structure** crumble apart, and now the wind is blowing that soil over here—and the sodium with it. It's even worse than before because my soil is crumbling now! Don't you see?! The walls are falling down around us!"

"Cousin, I thought I was coming to relax, but we have to do something about this."

"Well... rumour has it some new farmers are on their way, and they are bringing a small human. Perhaps the small one will listen to us?" says Tiger Beetle.

"Tiger, that's it!" exclaims Beetle "The small ones are usually good at taking our advice, so maybe there's hope! We can give them ideas to solve this. Why don't we read my textbook for some answers."

"Tiger! The human offspring has arrived! We have to give them guidance!" exclaims Beetle.

The beetle cousins wave to the child, who spots the beetles and kneels down curiously.

"Hello young human, we are here to warn you about about how these soils have been mismanaged and became super salty, and what you can do about it!" says Tiger.

Salty soils that are mismanaged can affect soil, plant, and microbial health[4]. This is particularly challenging for farmers since it could lead to crop losses, increases in management costs, and in some cases, total business loss and farm closure[5].

A couple of days later...

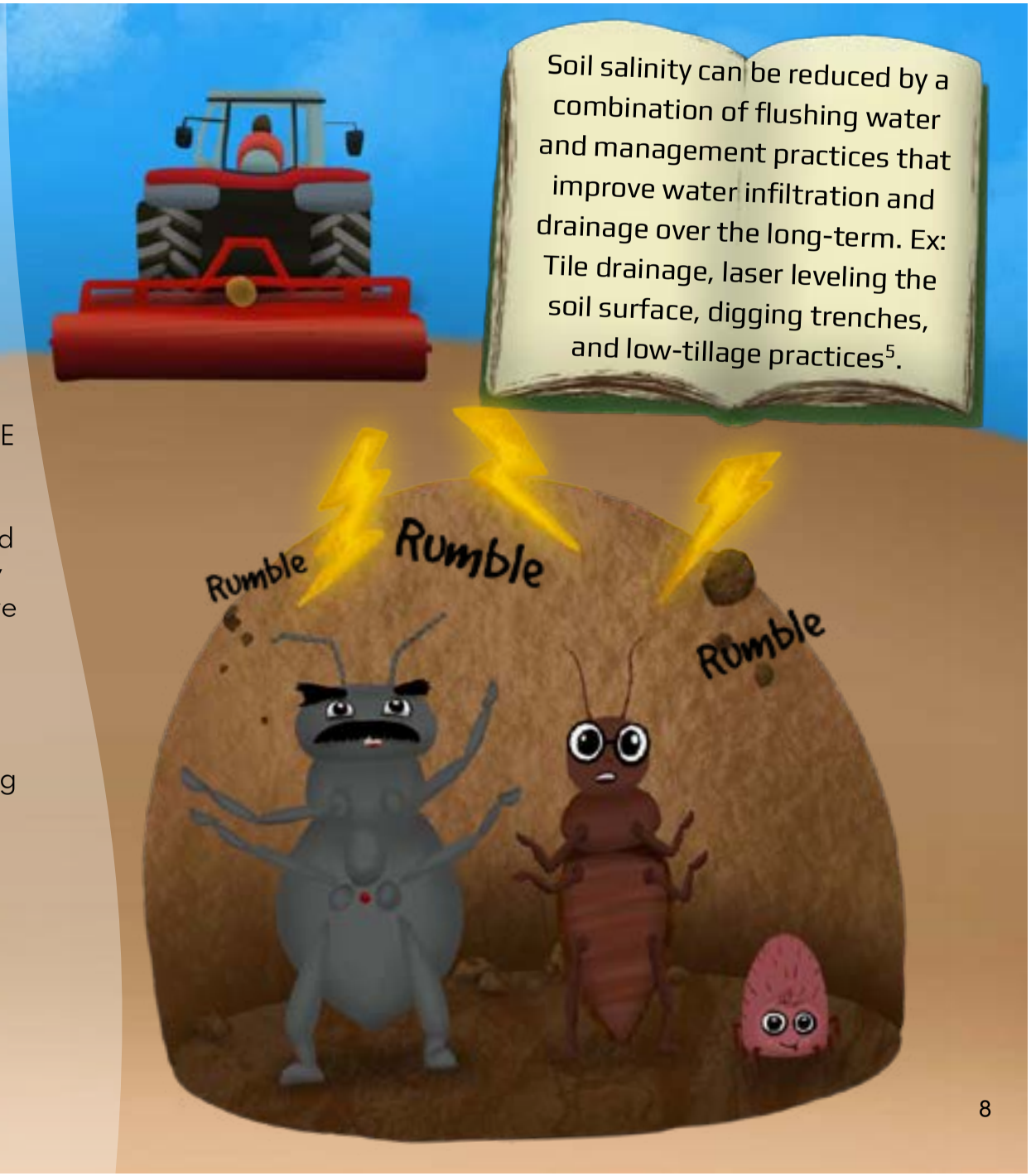
"WOOoow, what is that?! An earthquake?!" says Beetle.

"Look there! The humans are on their tractors! They are doing something to the soils..." says Tiger.

"OH NO! ARE THEY **TILLING**? WE HAVE TO GET OUT OF HERE NOW!" screams Beetle.

"Calm down Beetle! We just read about this: laser-levelling! They are making the soil surface more even. This way, the water has time to enter the soil instead of washing over the surface and taking soil with it," explains Tiger. "It seems they are listening to the tiny human we spoke to."

"OH YEAH!!" exclaims Beetle. "And over there I can see they are digging a trench around the farm. It must be for drainage. When it rains or the soil is watered, the salts will have a way to wash out."



A few days later….

"Tiger, your house is still falling apart and Mite is getting thirsty again," says Beetle

"I know Beetle," says Tiger. "The sodium salt is making the walls crack more and more with every minute that passes. "

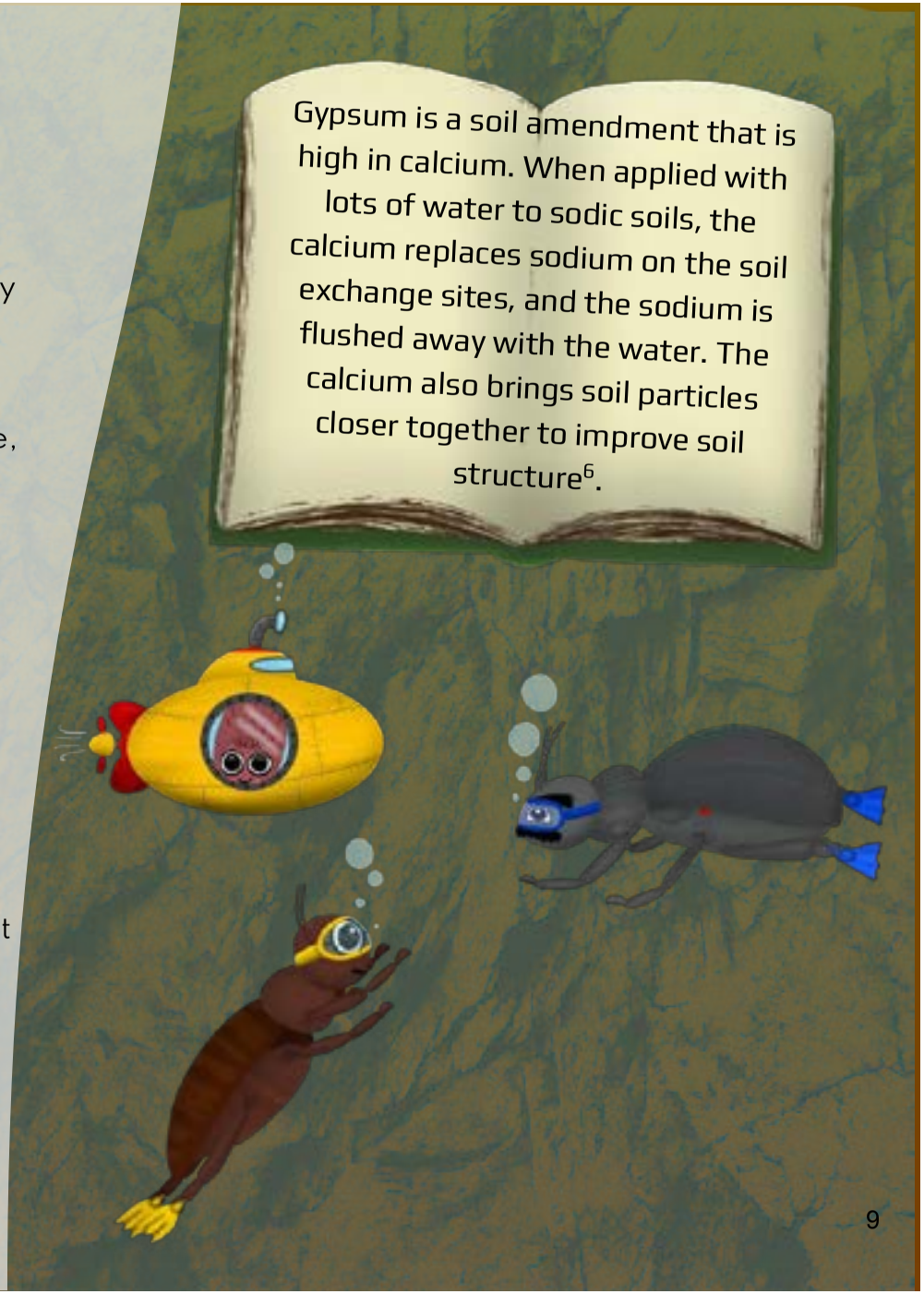
A rotten egg smell suddenly wafts into Tiger's house. "Ew, what's that smell?!" complains Beetle, covering his nose "Did you fart?"

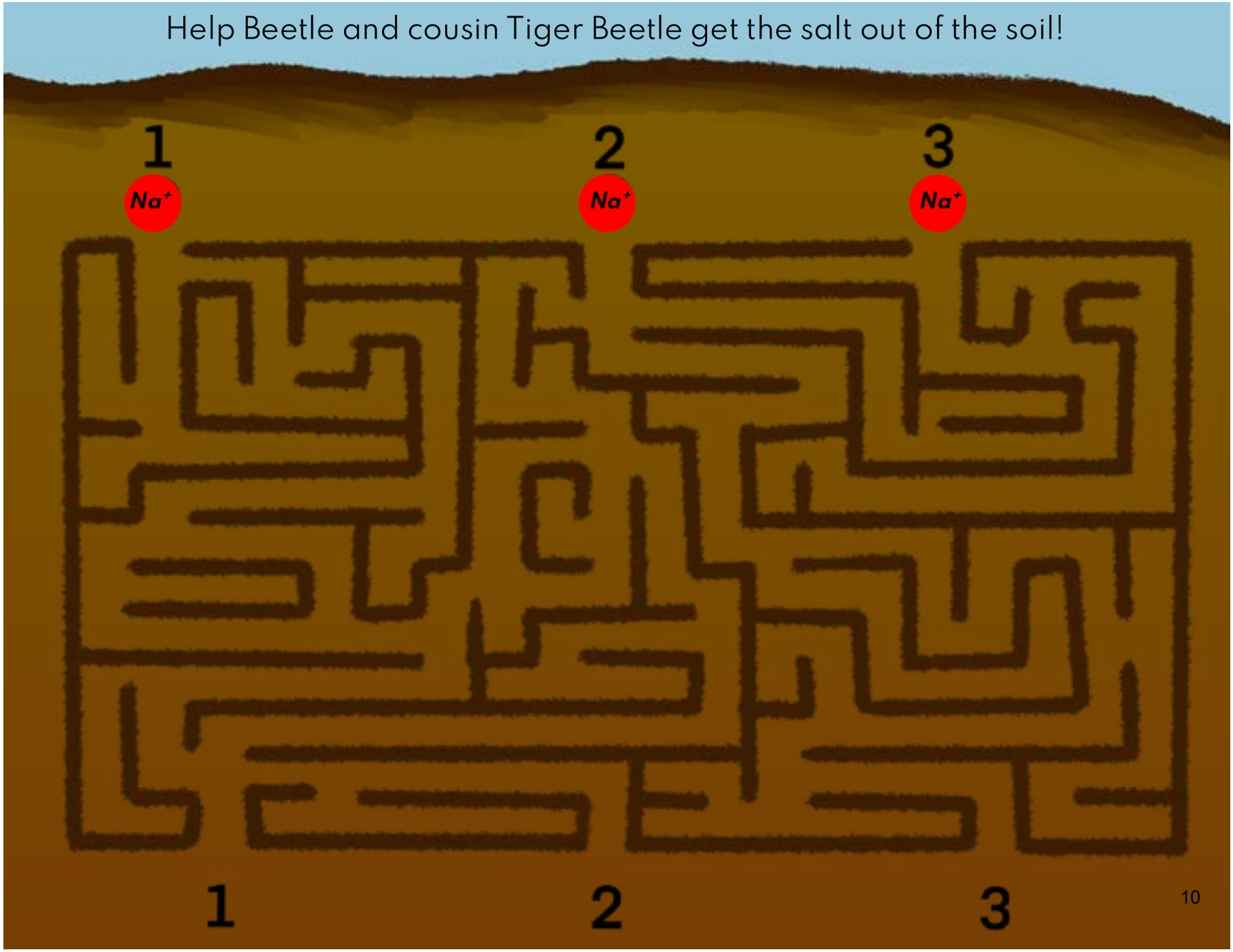
"Ha! It's the humans! They are spreading some type of powder in the soil, and it's pretty stinky!" says Tiger, as water sprinklers start spraying and the soil becomes wet. "And they are finally watering! Hold onto something we are about to get wet…"

Water starts rushing through the house, draining shortly afterwards.

"Well that is what I call a good soil bath. It's great for the cuticle! I feel rejuvenated" says Tiger. "And look, Mite doesn't look so thirsty anymore."

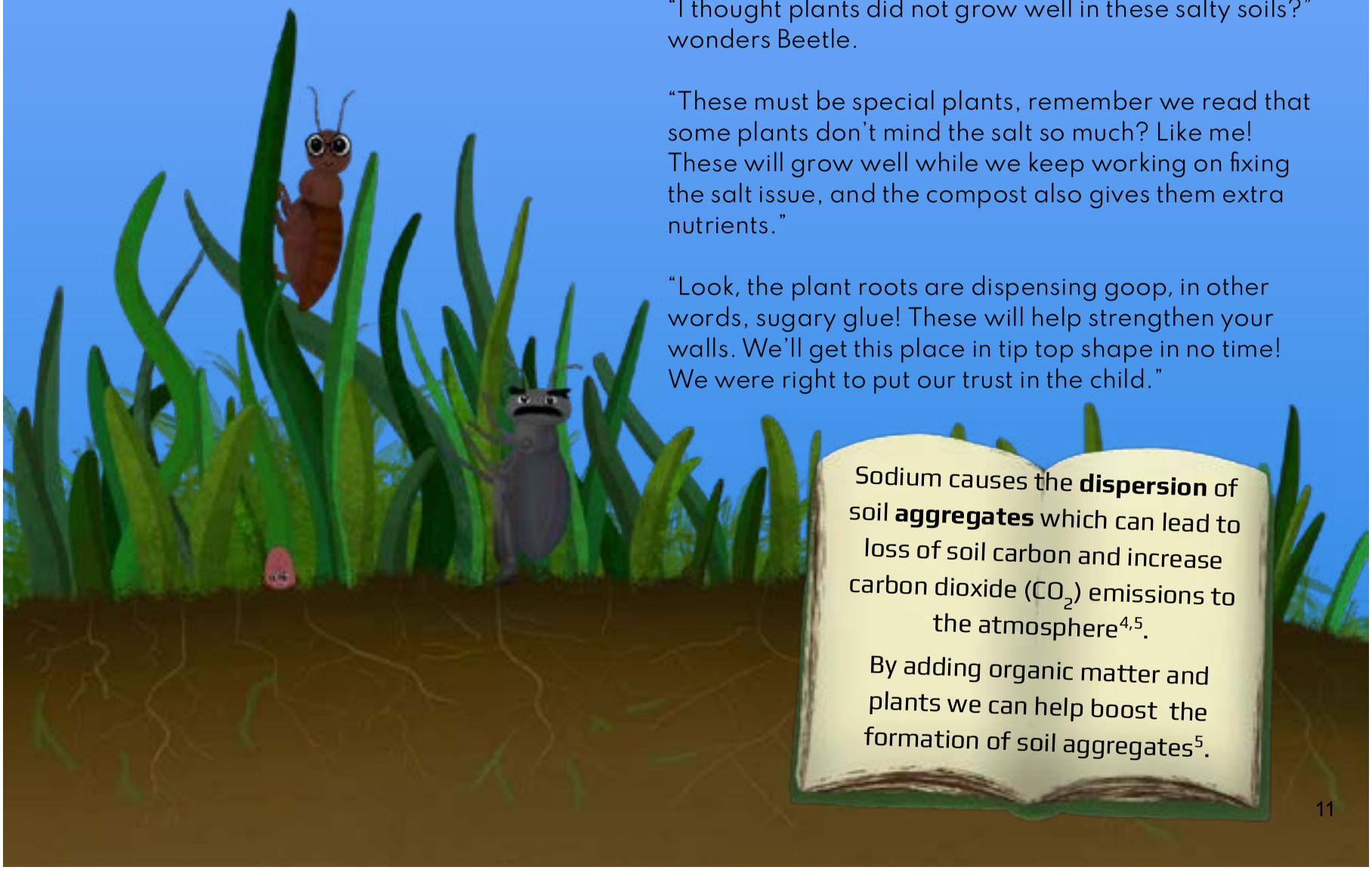
"Oh yes!" recalls Beetle. "This is the gypsum we read about. It helps get rid of the sodium, remember? Look cousin, your walls have stopped cracking! What the tiny human lacks in size, is made up for in brains!"




Help Beetle and cousin Tiger Beetle get the salt out of the soil!
1
2
3
Na+
Na+
Na+
1
2
3

A few weeks later...

"Well, things are looking better around here. But we still have some extra salts..." says Tiger Beetle "Look! I see the humans are planting and putting out some yummy **compost** too!



"I thought plants did not grow well in these salty soils?" wonders Beetle.

"These must be special plants, remember we read that some plants don't mind the salt so much? Like me! These will grow well while we keep working on fixing the salt issue, and the compost also gives them extra nutrients."

"Look, the plant roots are dispensing goop, in other words, sugary glue! These will help strengthen your walls. We'll get this place in tip top shape in no time! We were right to put our trust in the child."

Sodium causes the **dispersion** of soil **aggregates** which can lead to loss of soil carbon and increase carbon dioxide (CO_2) emissions to the atmosphere[4,5].

By adding organic matter and plants we can help boost the formation of soil aggregates[5].

A Farewell to Salt

Well, you might cook with salt and oil,
But too much salt will spoil our soil.
Plants will shrivel, friends will leave,
In **aggregates** it's hard to breathe.

Soil tests help us diagnose,
Salinity? Sodicity? How morose!
What to do to make it right?
Is our soily future bright?

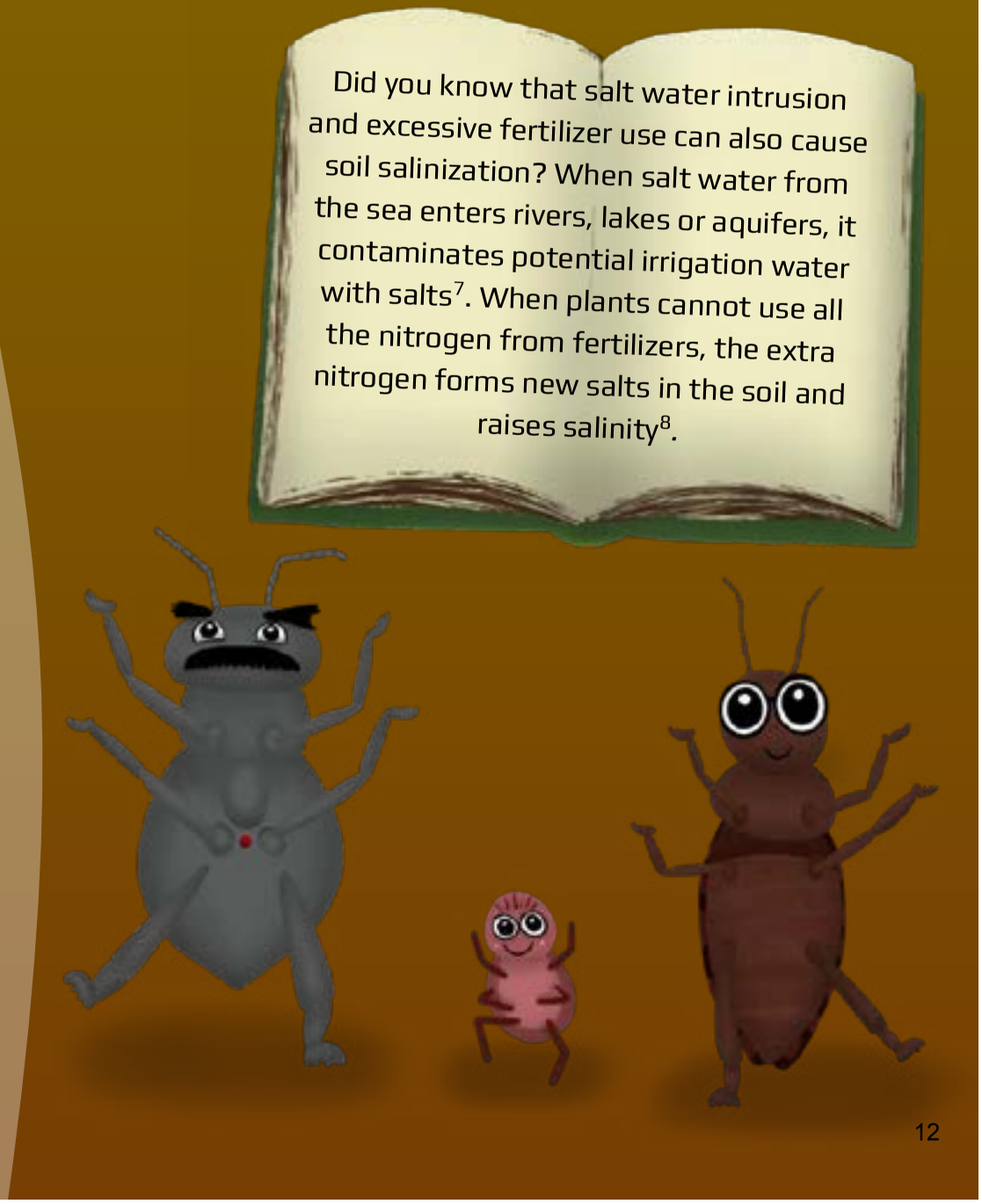
Don't give up, no don't despair—
With management we can repair!
Get some drainage, flush away,
But careful with your neighbours, eh!

When you water, know from where.
Could there be sea intrusion there?
Chemical fertilizers? Take it easy!
Too much extra makes us queasy.

Laser levelling's a tool,
To help stop runoff—very cool!
Add **compost**, mulch, **organic matter**,
Microbes will come—pitter patter!

You might even just decide
To make that field a set-aside
Once the salts have been reduced
biodiversity will have a boost!

See we can fix the situation,
If we halt soil **salinization**!
So treat soils well and carefully,
To boost soil productivity!



"I miss all my snacks and my friends. Maybe with all these improvements my friends will come back to live here," says Tiger.

"They will, trust me! I've seen it happen in my community! Just give it time."

"I hope you are right Beetle, I truly do." says Tiger. "Hey, I think I smell the gypsum again?!"

Halt soil salinization, boost soil productivity!

How to determine soil quality at home: Slaking or Dispersion Test

(Modified from: https://www.fao.org/fileadmin/templates/nr/kagera/Documents/LADA_manuals/part2_d.pdf)

Soil scientists use this test to determine soil quality. You can perform it at home with soils from your own region.
By adding table salt to one of your soil samples, you can observe how sodium affects soil structure.
Slaking describes how a soil aggregate (or clump of soil) will break down into smaller pieces or micro aggregates.
Dispersion describes the breakdown of these soil aggregates into smaller primary particles of sand, silt, and clay.

What you will need

- Soil
- 2 Glass jars (or clear containers)
- 2 teaspoons table salt (sodium chloride)
- Water

Steps

1. Find soil - for example, you can use soil from underneath the grass outside or soil from a garden bed. Find a large clump (or aggregate) of soil approximately 5 cm in diameter.
2. If the soil is wet, allow the soil aggregates to dry out for a day.
3. Fill two glass jars (or plastic containers) with water.
4. Add 2 teaspoons of salt to one of the cups of water. Mix well to dissolve the salt. Label to make sure you know which one is salty.
5. Drop an air-dried aggregate into each jar.
6. Completely submerge aggregates below the water.
7. After 10 minutes in the water, examine the aggregates to determine which one has slaked or dispersed more than the other.

Do the aggregates look the same? Which cup has muddier or cloudier water? Which aggregate held its shape better?

The soil aggregate that remained more intact is likely the soil without the added table salt. Other factors can affect the stability of soil aggregates. Higher amounts of organic matter, higher clay content, careful soil management (low tillage, direct seeding, mulching, cover crops, intercropping), biological activity (roots, fungi, worms), and physical processes (shrinking/swelling, wetting/drying) can all help soil aggregates stick together.

DID YOU KNOW?

Aggregates are mini clumps of soil made up of individual soil particles and organic matter that have bound together. Aggregates provide habitat for soil organisms, allow for air and water movement through the soil, create space for roots to grow, and store carbon.

Biodiversity refers to the many living organisms in a particular habitat, the more organisms the higher the biodiversity!

Carbon (C is the element of life. All living things are made of carbon and it is also in things that are not alive! This means that you, me, a giraffe, an apple, and a rock all have carbon within us.

Compost is a soil amendment made of partly decomposed organic matter. It is used to fertilize and improve the soil.

Dispersion is the process of soil particles separating from one another. This is often caused by an excess of sodium (Na in the soil and it is not desirable as it weakens soil structure and prevents aggregate formation.

An **ecosystem** is the physical area where organisms and nonliving factors (like water and air interact with one another.

Groundwater is water found underground in the space between rocks, sand, and soil.

Humus is a complex type of soil organic matter that has been transformed by decomposition. It is usually dark brown.

Infiltration is the process of water on the surface of the ground entering the soil.

Salinization is the process through which water-soluble salts build up in the soil.

Salt crusts are hard layers at the soil surface that form due to salinity.

Sodium (Na) is an element that readily forms salt compounds. High levels of sodium in soils can harm plants and cause the dispersion of aggregates. We commonly use sodium in cooking, because table salt (sodium chloride) is formed with sodium!

Soil is a layer of the Earth's surface, made up of interacting minerals (sand, silt, clay), organic matter, air, water, and living organisms. It is where we grow food and is vital for ecosystem functions. Soil is not dirt!

Soil organic matter refers to the dead plant and animal tissues at different stages of decomposition in the soil.

Soil Structure is the relative arrangement of soil particles in the soil. This organization is dependent on how these particles clump and bind together to form different types of soil aggregates.

Tilling is the mechanical action of overturning and crumbling the soil to prepare it for cultivation of crops. This is mainly done by heavy machinery (tractors) and often leads to the destruction of many insect habitats.

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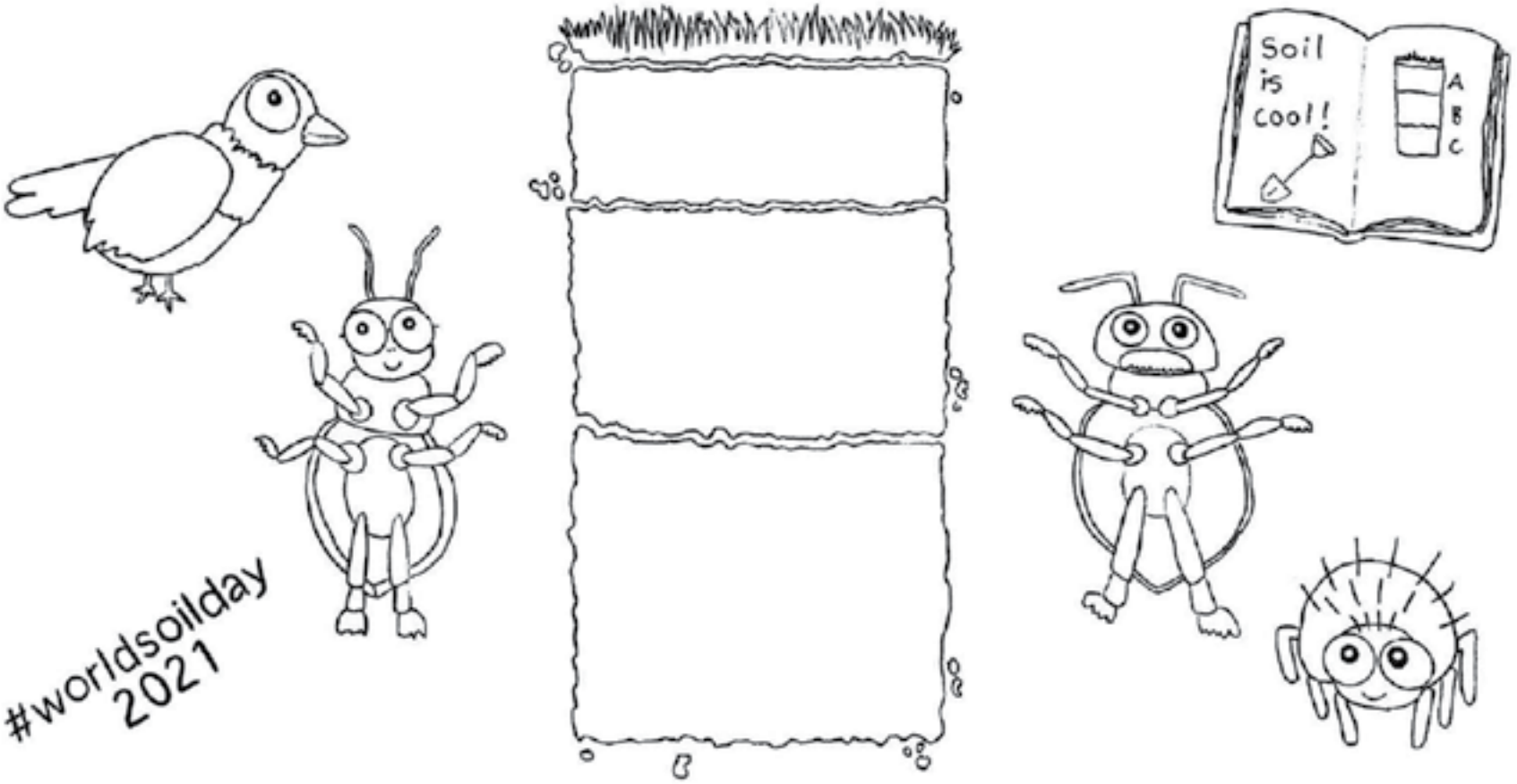
Halt Soil Salinization



Boost Soil Productivity

Earth's Extraordinary Soil for All Living Organisms

Learning, thinking and acting!

Author

Marcela Bianchessi da Cunha Santino is an associate professor at the Universidade Federal de São Carlos in Brazil, where she received her M.S. and PhD in Science. She devotes her career to teaching environmental sciences disciplines (Limnology, Environmental Monitoring and Biogeochemical Cycles and Pollution), and her research interests focus on active methodology for learning. In addition, she creates content-based instructional materials, to engage lecture and laboratory students in critical thinking, and investigative practices. Her research focuses on Aquatic Sciences, particularly in macrophyte ecology. The booklet Earth's extraordinary soil for all living organisms - Learning, thinking, and acting! was developed to disseminate scientific knowledge about salinization to children and youth. Its information is scientifically based on specialized literature. The booklet's host is an earthworm called Lumbricus who will take the reader on an extraordinary edaphic journey.

EARTH'S EXTRAORDINARY SOIL FOR ALL LIVING ORGANISMS

Learning, thinking, and acting!


MY NAME IS LUMBRICUS, I AM THE AMBASSADOR OF THE SOIL.
I WILL TAKE YOU ON THIS FABULOUS EDAPHIC JOURNEY.

FIRST, WE NEED TO UNDERSTAND WHAT SOIL IS!

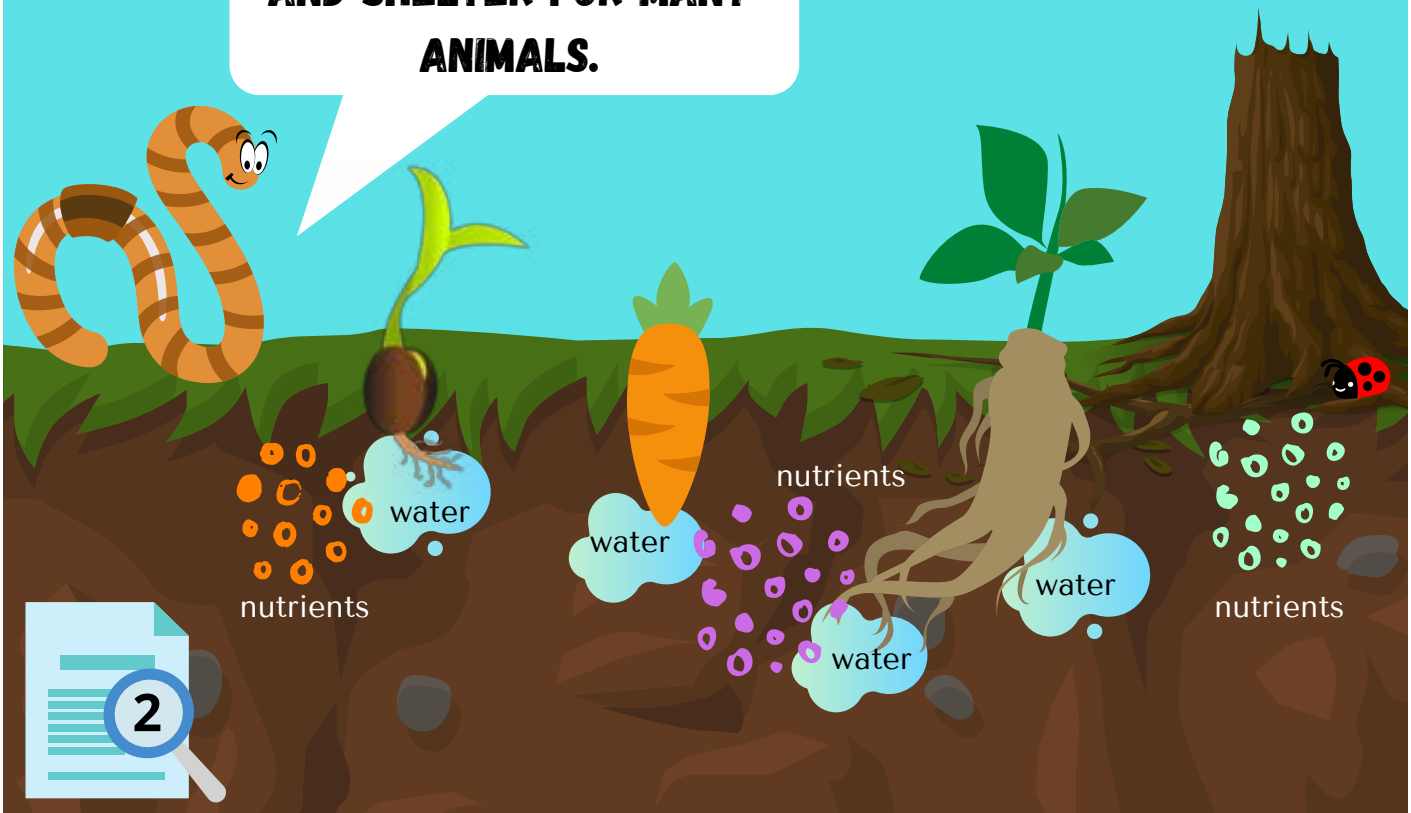
SOIL IS MADE UP OF SOLID PARTICLES AND PORE SPACES.

SOIL PORE SPACES ARE FILLED WITH WATER, AIR, AND A LOT OF ORGANISMS.

LET'S LEARN ABOUT THE IMPORTANCE OF SOIL!

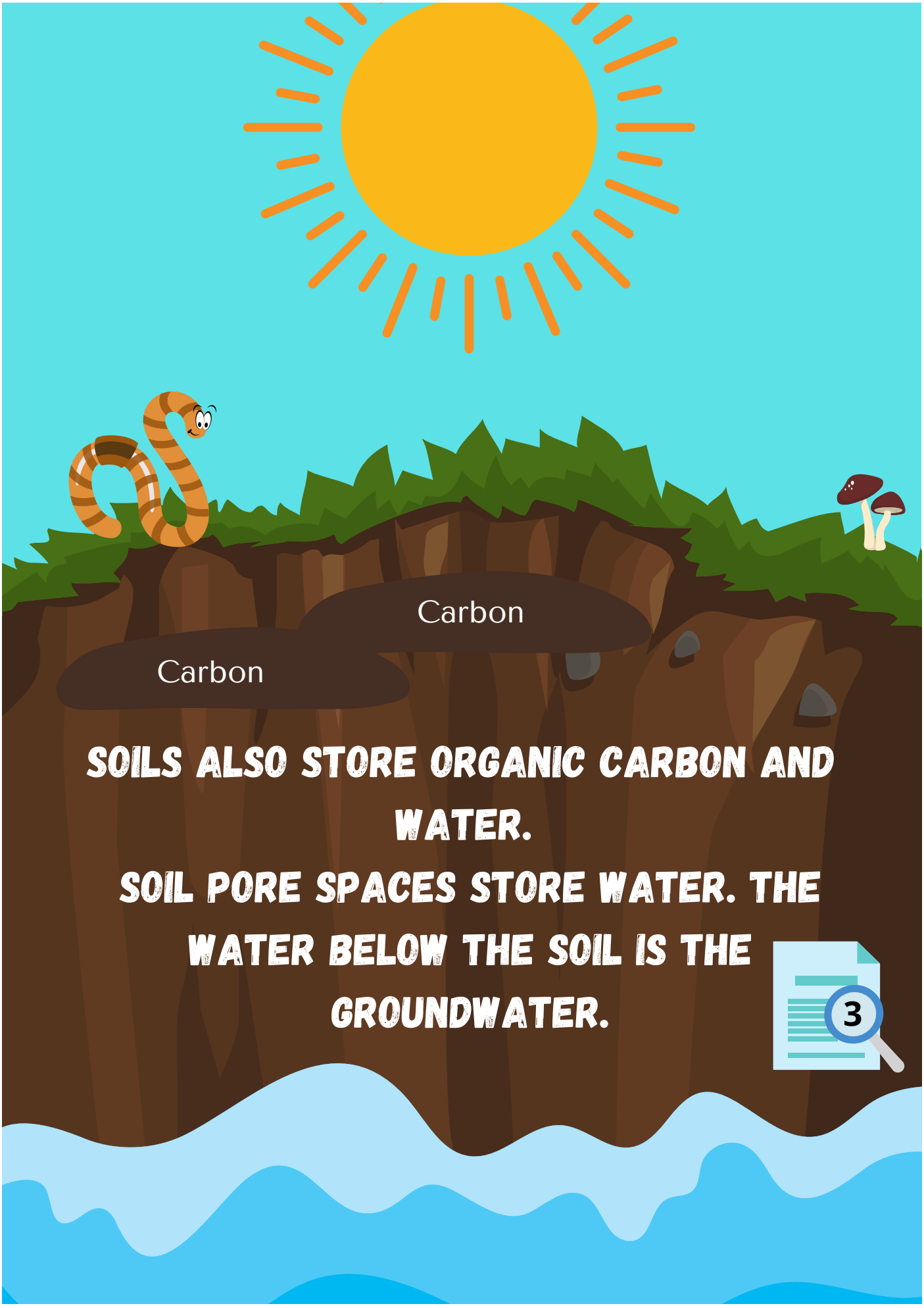
HAVE YOU EVER THOUGHT ABOUT THE IMPORTANCE OF SOIL?
AND ABOUT THE BENEFITS WE CAN GET FROM SOIL?

SOIL SUPPORTS BIODIVERSITY, PROVIDING HABITAT, FOOD, WATER, AND SHELTER FOR MANY ANIMALS.



SOIL IS THE NATURAL MEDIUM FOR THE GROWTH OF LAND PLANTS. SOILS STORE NUTRIENTS AND WATER, AND SUPPORT ROOTS GROWTH THAT SUSTAIN CROPS. CROPS PROVIDE FOOD, FIBER, AND FUEL FOR US.

SOIL IS WHERE WE BUILD THE INFRASTRUCTURE WE USE IN OUR DAY-TO-DAY, SUCH AS HOUSES, SHOPS, SCHOOLS, CROPS, AND PASTURES.


Carbon
Carbon
SOILS ALSO STORE ORGANIC CARBON AND WATER.
SOIL PORE SPACES STORE WATER. THE WATER BELOW THE SOIL IS THE GROUNDWATER.
3

LET'S UNDERSTAND THE ENVIRONMENTAL PROBLEMS RELATED TO SOILS!

SOIL POLLUTION IS WIDESPREAD. SOIL DEGRADATION LEADS TO THE LOSS OF NUTRIENTS, BIODIVERSITY, AND STORED CARBON.

OH NO!
SEVERAL BENEFITS ARE LOST BY SOIL DEGRADATION.

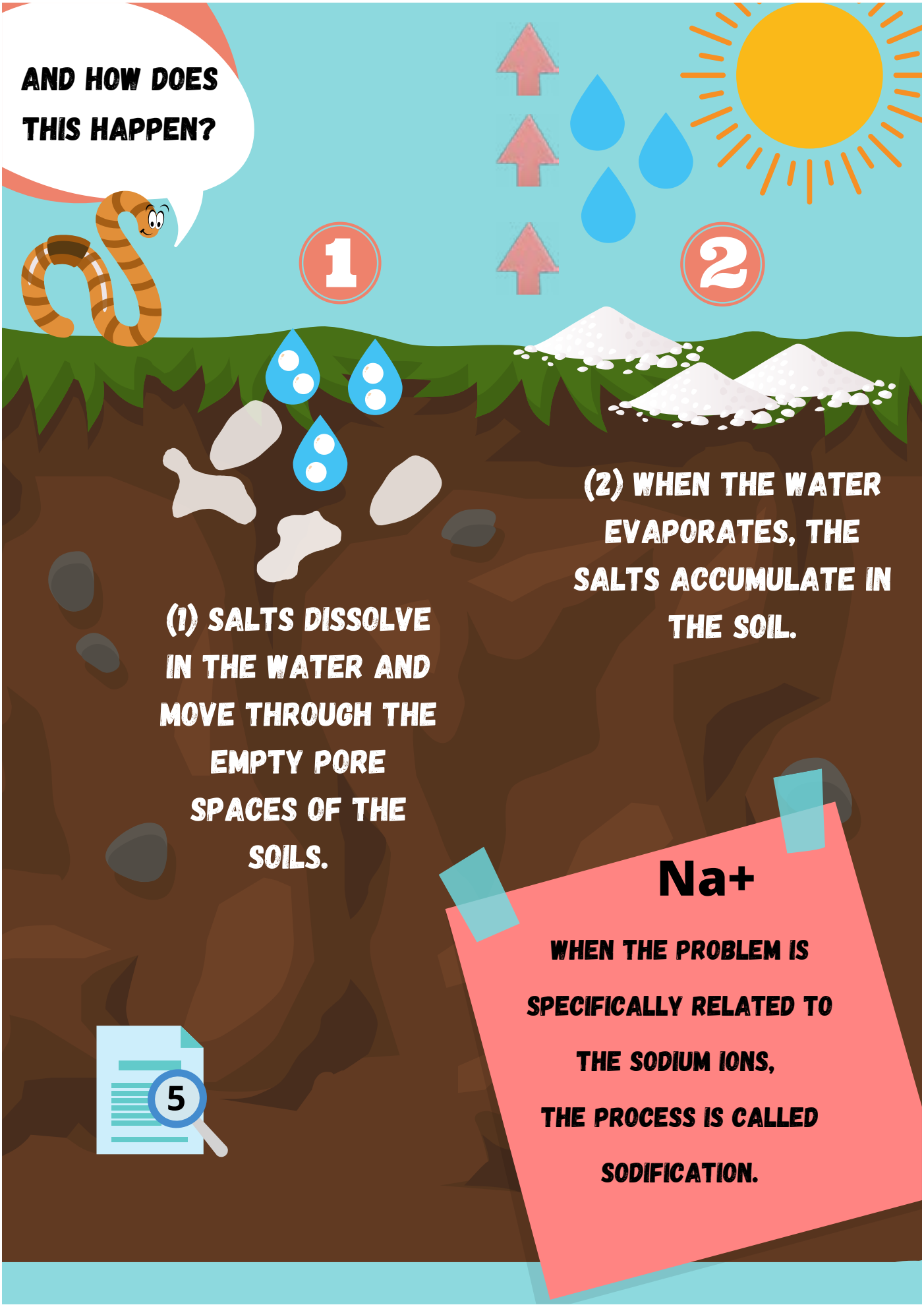
SOIL SALINITY IS ONE OF THE MOST

WIDESPREAD TYPE OF SOIL DEGRADATION.

PROCESSES OF SALINIZATION AND SODIFICATION ARE A GLOBAL ENVIRONMENTAL ISSUE THAT AFFECTS ALL LIVING ORGANISMS.

SALINIZATION AND SODIFICATION THREATEN THE BENEFITS PROVIDED BY SOIL.


WHAT IS SALINIZATION?
SOIL SALINIZATION RESULTS FROM AN EXCESS OF SALTS.
SALINIZATION REFERS TO THE TOTAL SALT CONCENTRATION IN THE SOIL, INCLUDING SODIUM, POTASSIUM, MAGNESIUM, CALCIUM AND, CHLORIDE IONS.
5
THE SOURCE OF SALTS IN SOIL CAN BE NATURAL OR ANTHROPOGENIC. FOR EXAMPLE, NATURAL SOURCES REFER TO WEATHERING OF ROCKS. MAN-INDUCED SOURCES INCLUDE SALTS PRESENT IN IRRIGATION WATERS, ANIMAL WASTES AND SYNTHETIC FERTILIZERS USED IN FARMING ACTIVITIES.
Fertilizer


AND HOW DOES THIS HAPPEN?
1
2
(1) SALTS DISSOLVE IN THE WATER AND MOVE THROUGH THE EMPTY PORE SPACES OF THE SOILS.
(2) WHEN THE WATER EVAPORATES, THE SALTS ACCUMULATE IN THE SOIL.
5
Na+
WHEN THE PROBLEM IS SPECIFICALLY RELATED TO THE SODIUM IONS, THE PROCESS IS CALLED SODIFICATION.

SALINIZATION AND SODIFICATION REDUCE SOIL QUALITY AND, CONSEQUENTLY, VEGETATION COVER ON THE SOIL.

THE EXCESS OF SALTS DESTROYS THE SOIL STRUCTURE, CAUSING LOSS OF FERTILITY AND REDUCING PLANT GROWTH. THUS, CROP PRODUCTIVITY COLLAPSES.

ALSO, SALINIZATION AND SODIFICATION CHANGE LOCAL CLIMATIC CONDITIONS, AFFECTING SOIL BIODIVERSITY AND THE QUALITY AND QUANTITY OF THE GROUNDWATER.

LET´S THINK ABOUT WHAT SALINIZATION AND SODIFICATION DO TO SOIL!

ONE OF THE BIGGEST THREATS TO OUR FUTURE IS THE LOSS IN SOIL PRODUCTIVITY. IF WE REMEMBER THE BENEFITS OF SOIL, SODIFICATION AND SALINIZATION WILL AFFECT IN A BAD WAY THE QUALITY AND QUANTITY OF THE FOOD WE EAT AND THE WATER WE DRINK.

LET´S TAKE ACTION!

LET´S SPREAD A "SEED OF INFORMATION" SO ALL PEOPLE CAN KNOW ABOUT THE IMPORTANCE AND THE ENVIRONMENTAL PROBLEMS THAT AFFECT SOIL QUALITY.

CREATE A PODCAST OR A FLYER WITH ALL THE INFORMATION YOU LEARNED AND SPREAD IT TO YOUR COLLEAGUES, NEIGHBORS, AND FAMILY.

LET´S TELL PEOPLE A LITTLE MORE ABOUT SOIL SALINIZATION AND SODIFICATION, AND HOW IT'S IMPORTANT TO DISCUSS THESE ENVIRONMENTAL PROBLEMS WITH SCIENTISTS, POLITICIANS, AND THE COMMUNITY.

DISCUSSION ON SUSTAINABLE SOIL MANAGEMENT (AS BEST MANAGEMENT ON IRRIGATION AND FERTILIZATION PRACTICES, REFORESTATION, AGROFORESTRY) WILL HELP US KEEP THE SOIL HEALTHY FOR ALL LIVING ORGANISMS ON EARTH.


LET´S
HALT SOIL SALINIZATION,
BOOST SOIL
PRODUCTIVITY

TOGETHER!


5 DECEMBER 2021
World Soil Day
Halt soil salinization,
boost soil productivity

Why can't crops be grown in the fields?

Author

Song Zikang is a junior student in the China University of Geosciences, Beijing. His research field is land reclamation, ecological restoration, and territorial space planning. The management of soil salinization is one aspect of his study. He is passionate about making a contribution to the cause of soils, which are vital to food security and affect everyone. He believes that the study of soil salinization can lead children to think about saving food and protecting land, and that maybe they will work on soils in the future. This booklet provides a basic explanation of soil salinization for children aged 6-11. The ideological line is to find the problem- put forward the problem - explain the cause of the problem - put forward the solution to the problem. The content mainly includes the process of soil salinization and the causes of soil salinization. At the end of the book, the relationship between soil salinization and children themselves is described step by step, to stimulate their awareness of environmental protection and soil protection.

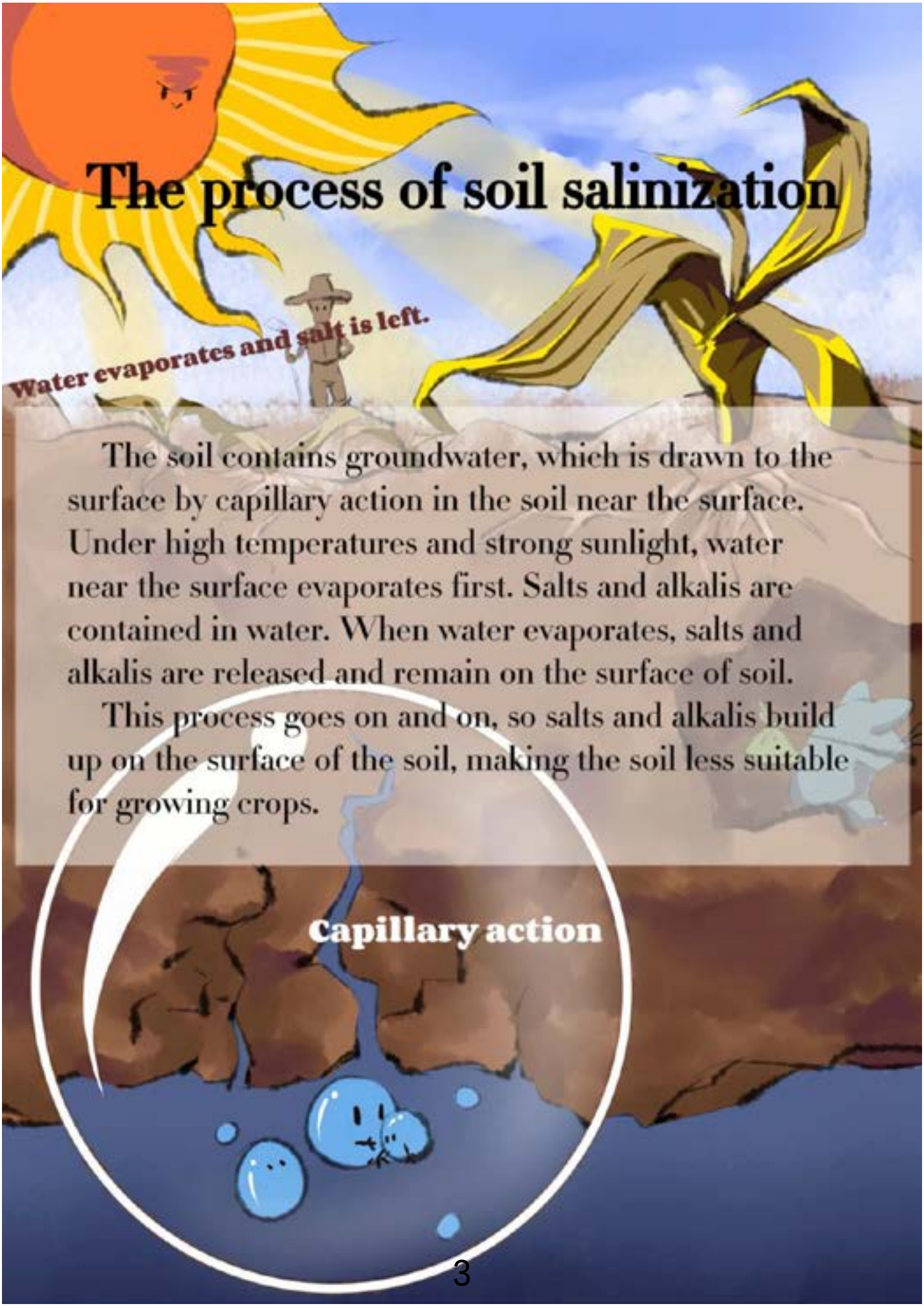

Why can't crops be grown
in the fields?

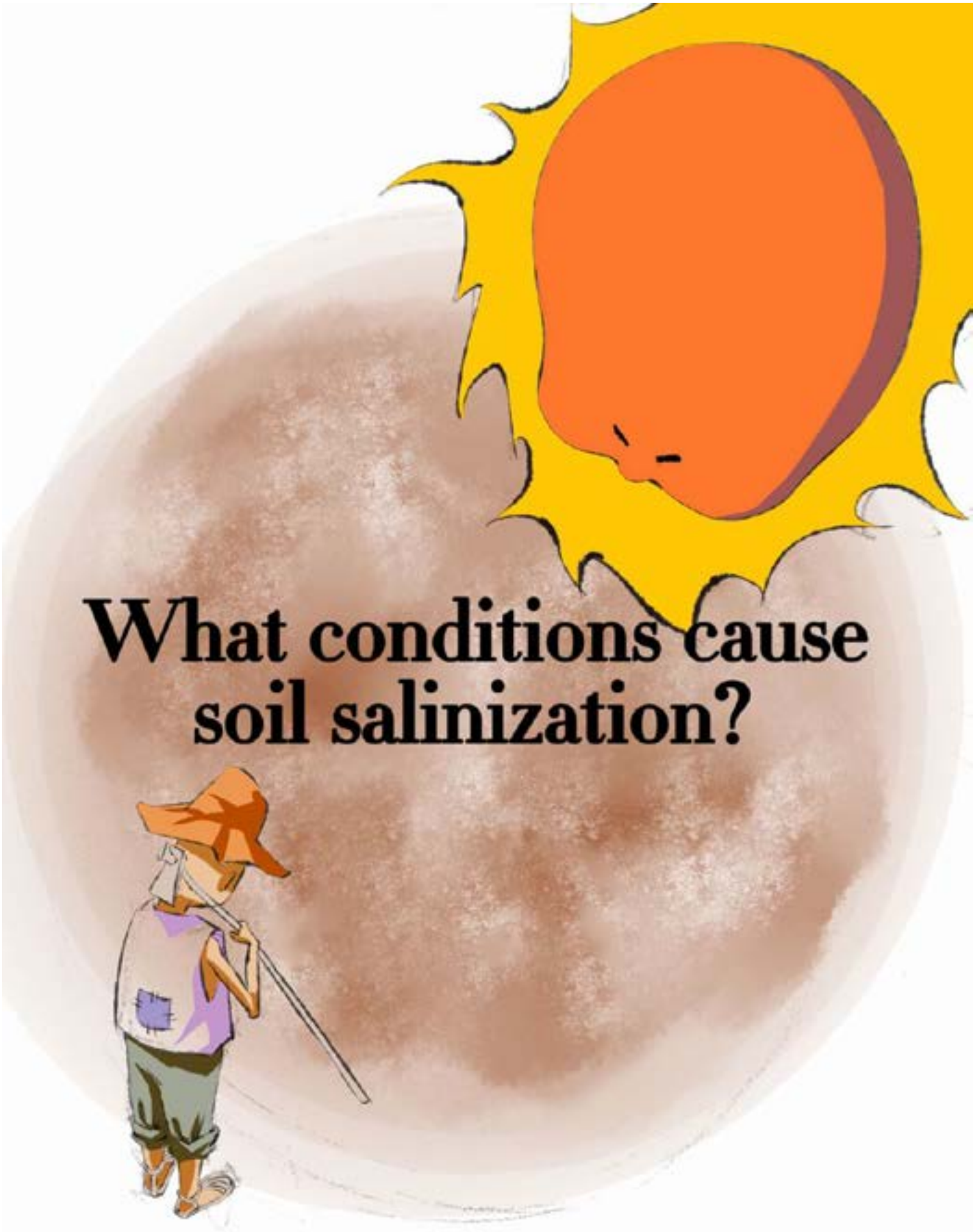

Why doesn't it work even if I water and fertilize it?
There are many fields in the world whose surface is so white that crops cannot live on them, which affects people's demand for food.
But why didn't these crops grow?
1

It turns out that these lands are saline-alkal.

If the concentration of salts and alkalis is too high in saline-alkali soil, the plant will lose water seriously in saline-alkali soil, resulting in cell death. Just like freshwater fish can't survive in the ocean. The process of forming saline-alkali land is called soil salinization.

2


The process of soil salinization
Water evaporates and salt is left.
The soil contains groundwater, which is drawn to the surface by capillary action in the soil near the surface. Under high temperatures and strong sunlight, water near the surface evaporates first. Salts and alkalis are contained in water. When water evaporates, salts and alkalis are released and remain on the surface of soil.
This process goes on and on, so salts and alkalis build up on the surface of the soil, making the soil less suitable for growing crops.
Capillary action
3



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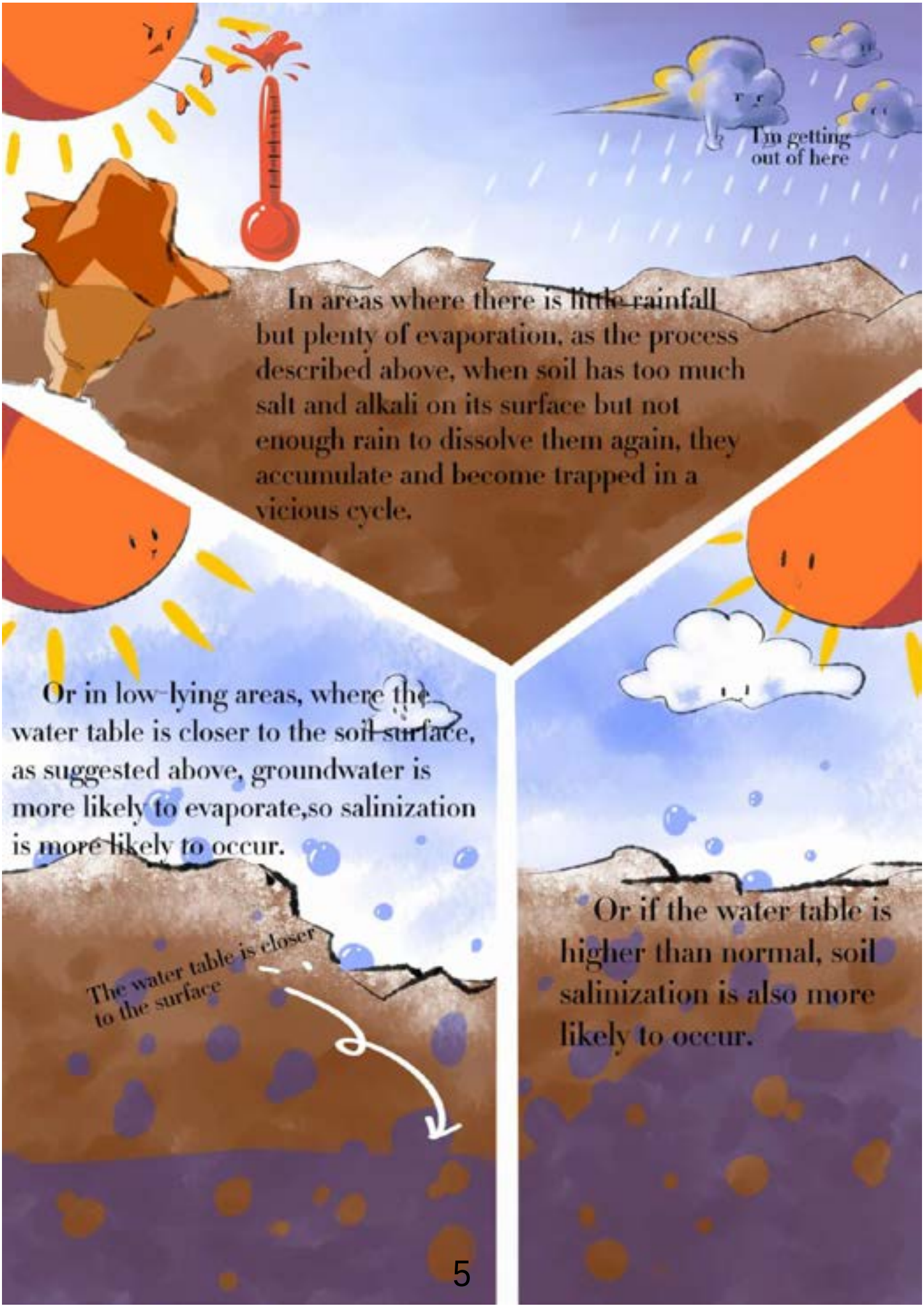
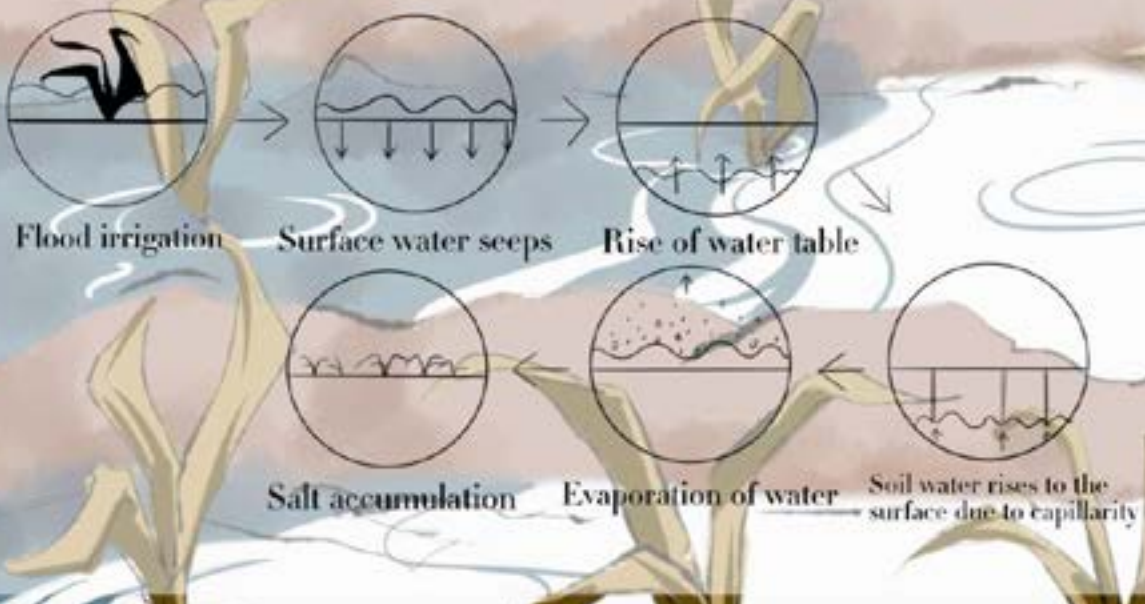

I'm getting out of here
In areas where there is little rainfall but plenty of evaporation, as the process described above, when soil has too much salt and alkali on its surface but not enough rain to dissolve them again, they accumulate and become trapped in a vicious cycle.
Or in low-lying areas, where the water table is closer to the soil surface, as suggested above, groundwater is more likely to evaporate,so salinization is more likely to occur.
The water table is closer to the surface
Or if the water table is higher than normal, soil salinization is also more likely to occur.
5

Human Activities

Human activities are also one of the important causes of soil salinization. Unreasonable irrigation measures such as flood irrigation and delayed drainage.

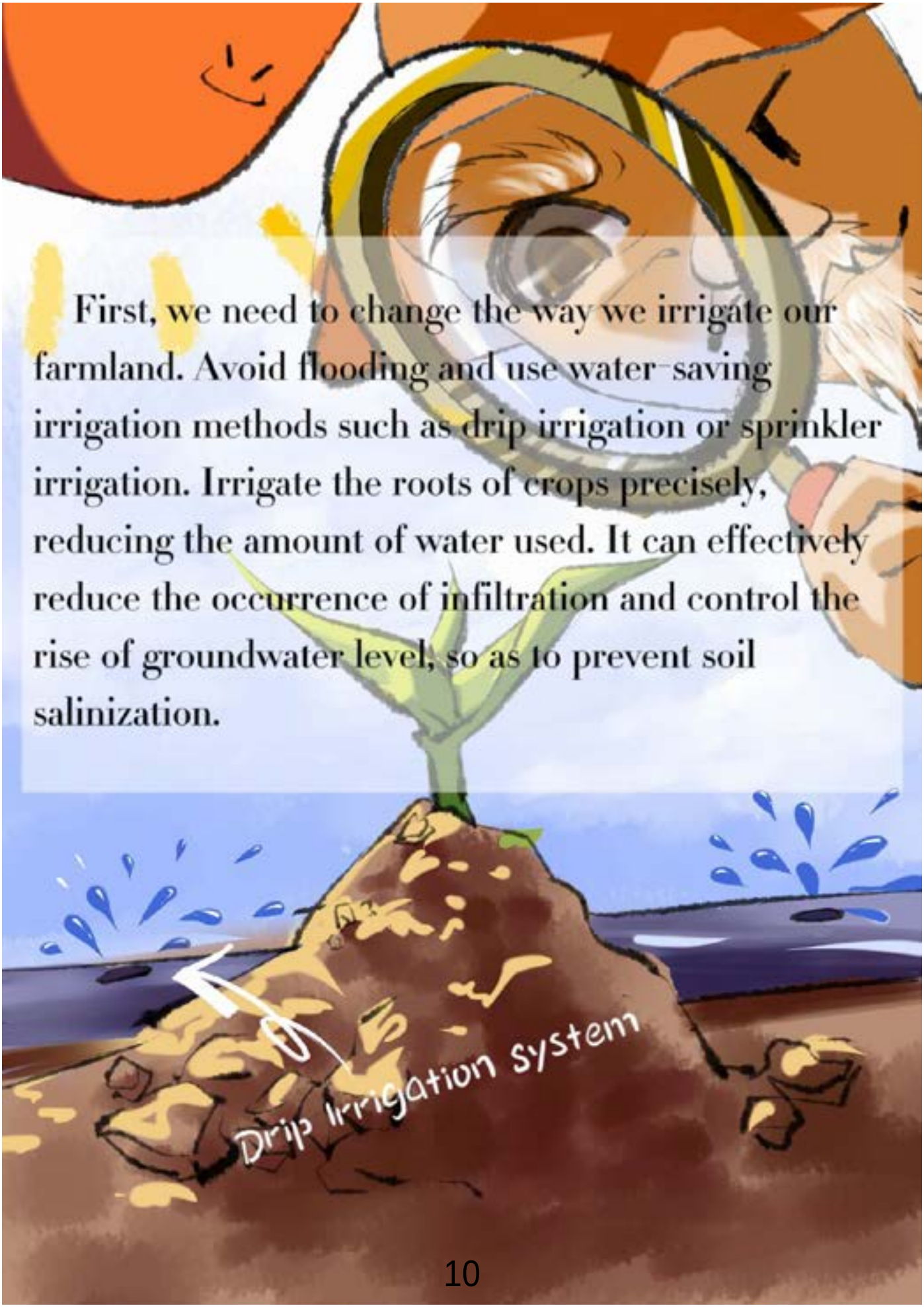
In order to improve the agricultural production, agricultural production in large areas of irrigation, if lack of enough in the process of irrigation and drainage facilities, easy to cause underground water level to rise, makes the soil capillary action to enhance water, stay in the soil, only by evaporation way to persist, making salt accumulation in the soil, soil salinity problem getting worse.

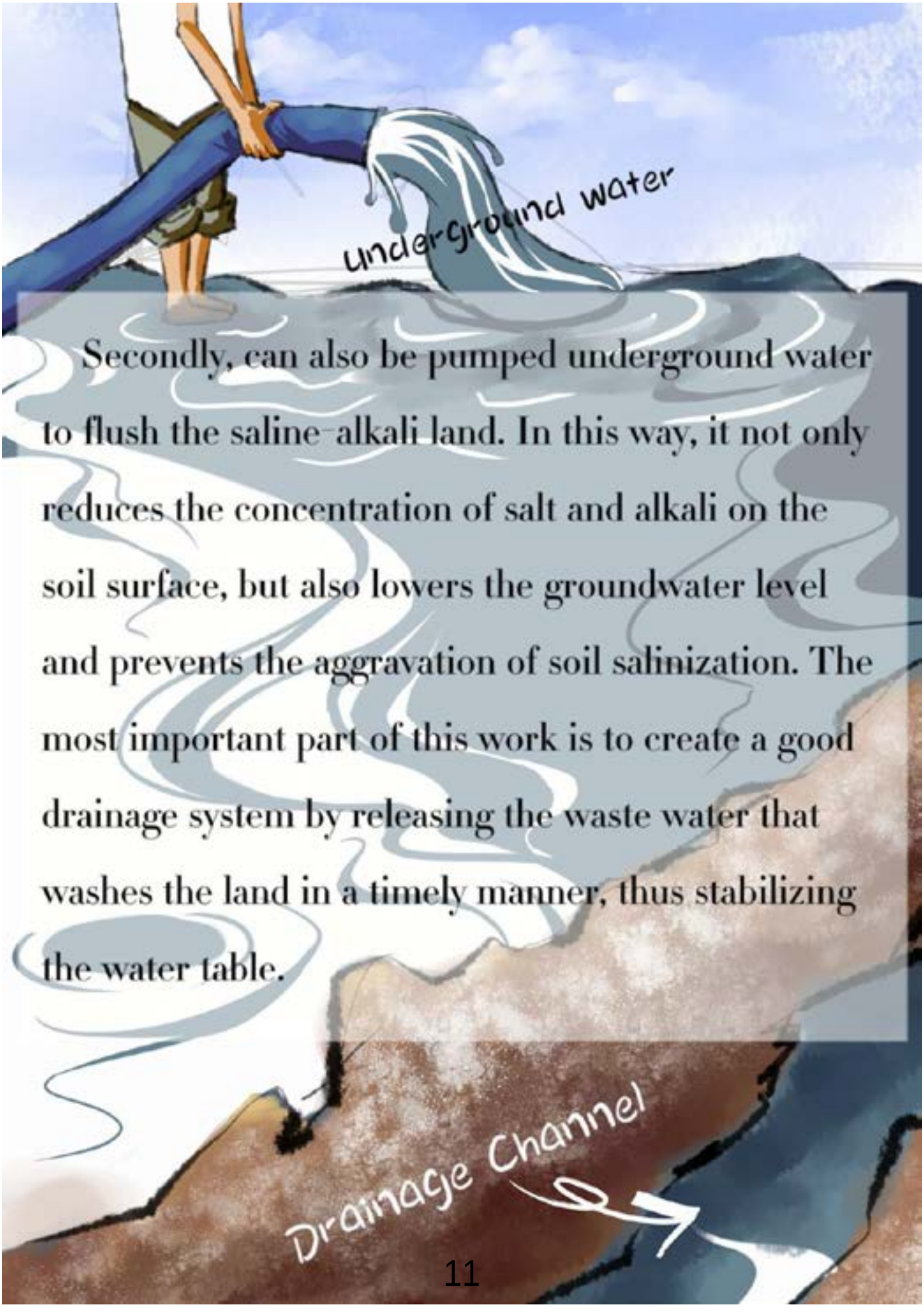


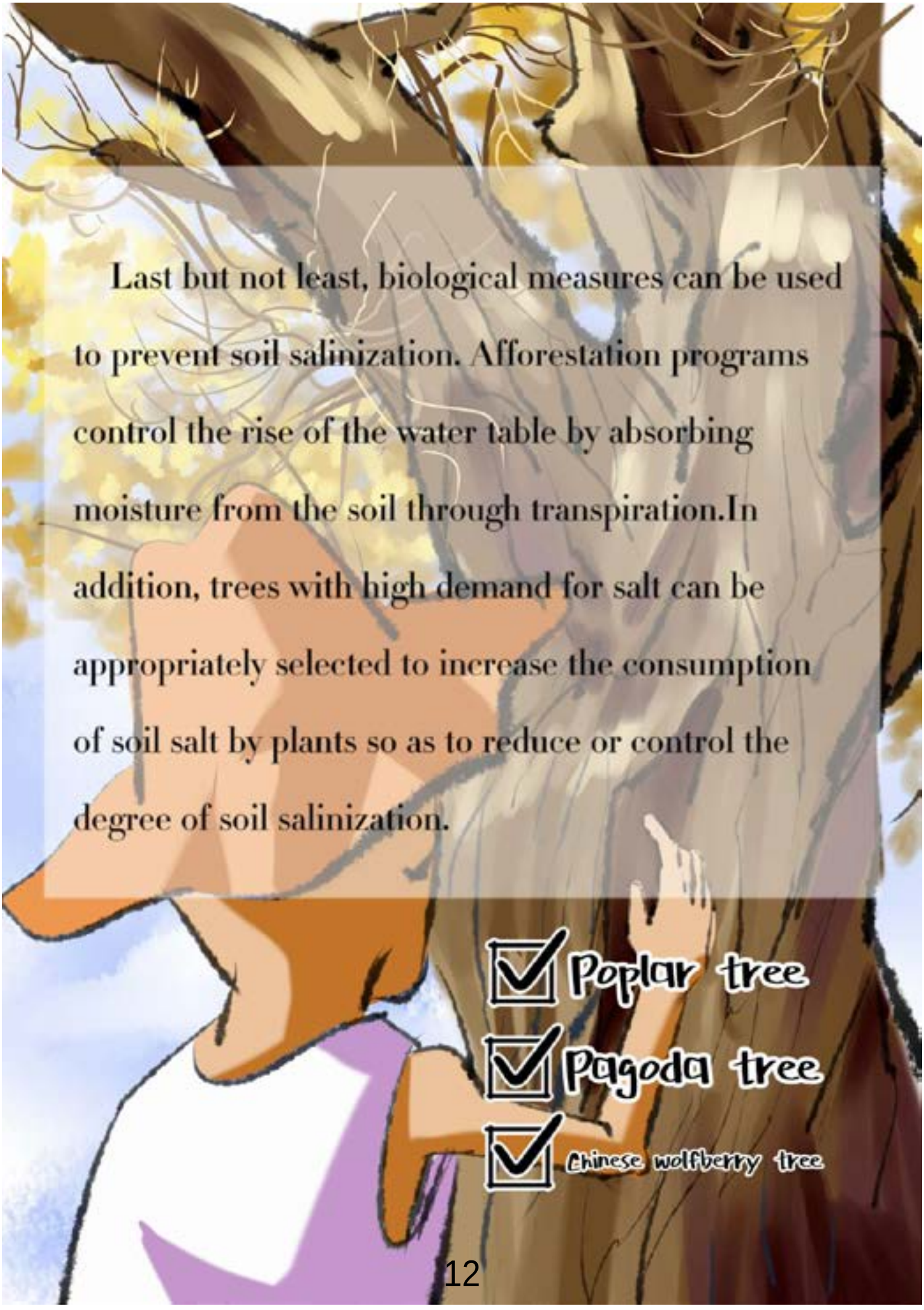

What is our ultimate goal
Since soil salinization has such a great impact on the growth of crops and causes serious land waste, we must pay attention to it.
Our ultimate goal is to "Halt soil salinization, Boost soil productivity".
Soil salinization can be stopped by changing irrigation practices, while soil productivity can be improved through fertilization and rational planting.
7

8


Growing
guide
9


First, we need to change the way we irrigate our farmland. Avoid flooding and use water-saving irrigation methods such as drip irrigation or sprinkler irrigation. Irrigate the roots of crops precisely, reducing the amount of water used. It can effectively reduce the occurrence of infiltration and control the rise of groundwater level, so as to prevent soil salinization.
Drip Irrigation System
10


Underground water
Secondly, can also be pumped underground water to flush the saline-alkali land. In this way, it not only reduces the concentration of salt and alkali on the soil surface, but also lowers the groundwater level and prevents the aggravation of soil salinization. The most important part of this work is to create a good drainage system by releasing the waste water that washes the land in a timely manner, thus stabilizing the water table.
Drainage Channel
11

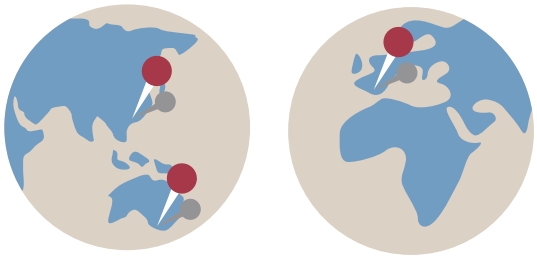

Last but not least, biological measures can be used to prevent soil salinization. Afforestation programs control the rise of the water table by absorbing moisture from the soil through transpiration.In addition, trees with high demand for salt can be appropriately selected to increase the consumption of soil salt by plants so as to reduce or control the degree of soil salinization.
Poplar tree
Pagoda tree
Chinese wolfberry tree
12


Sensors inserted into the soil
After the prevention and treatment of soil salinization, it is necessary to carry out real-time monitoring of soil and groundwater level and adjust the balance of soil salt and alkali in time if we want to continue to develop well.
soil salinity tester

13


What can we do
Preventing soil salinization is not just a job for scientists. It requires the efforts of all of us. Through independent innovation, advocacy and action to protect the limited land resources on the earth.
In some parts of the world, poor people still starve to death without enough to eat. Only by working together can we truly prevent and control soil salinization and improve land productivity.
14

Cookie's Apple Dream



Authors

Frederick Dadzie is a PhD student at UNSW Sydney, whose research focuses on the use of microorganisms to enhance land restoration in dryland ecosystems. He is passionate about science communication to younger and less privileged communities and actively promotes all-inclusive science education.

Chen Han comes from China and now she is a PhD student in Chemical Engineering, UNSW Sydney, Australia. Her research is about protecting the environment and solving the energy crisis. She cares about our planet.

Ao Chen is a college student from China who is studying landscape architecture. Painting is her biggest hobby, and she hopes that every creation can break through herself and present a better visual experience to the audience.

Miriam Muñoz-Rojas is a Senior Research Fellow at the University of Seville and Honorary Senior Lecturer at UNSW Sydney. Her research is focused on the ecology and restoration of terrestrial ecosystems. She is involved in several initiatives and committees (European Geosciences Union and International Union of Soil Sciences) to support soil and ecosystem researchers, particularly young scientists, across the world.

Cookie's Apple Dream

Written by Frederick Asankom Dadzie, Chen Han
Illustrated by Ao Chen Art designed by Chen Han

Cookie is a cat and her favourite foods are fish and apples. She likes apples because they are sweet, juicy, and full of Vitamin C!

Cookie lives with her family and many friends in a small coastal city. Her parents have a farm which is not doing very well. So, she decided to plant an apple tree in spring so that she can eat apples at all times and also sell to earn money. She will use the money to buy fish.

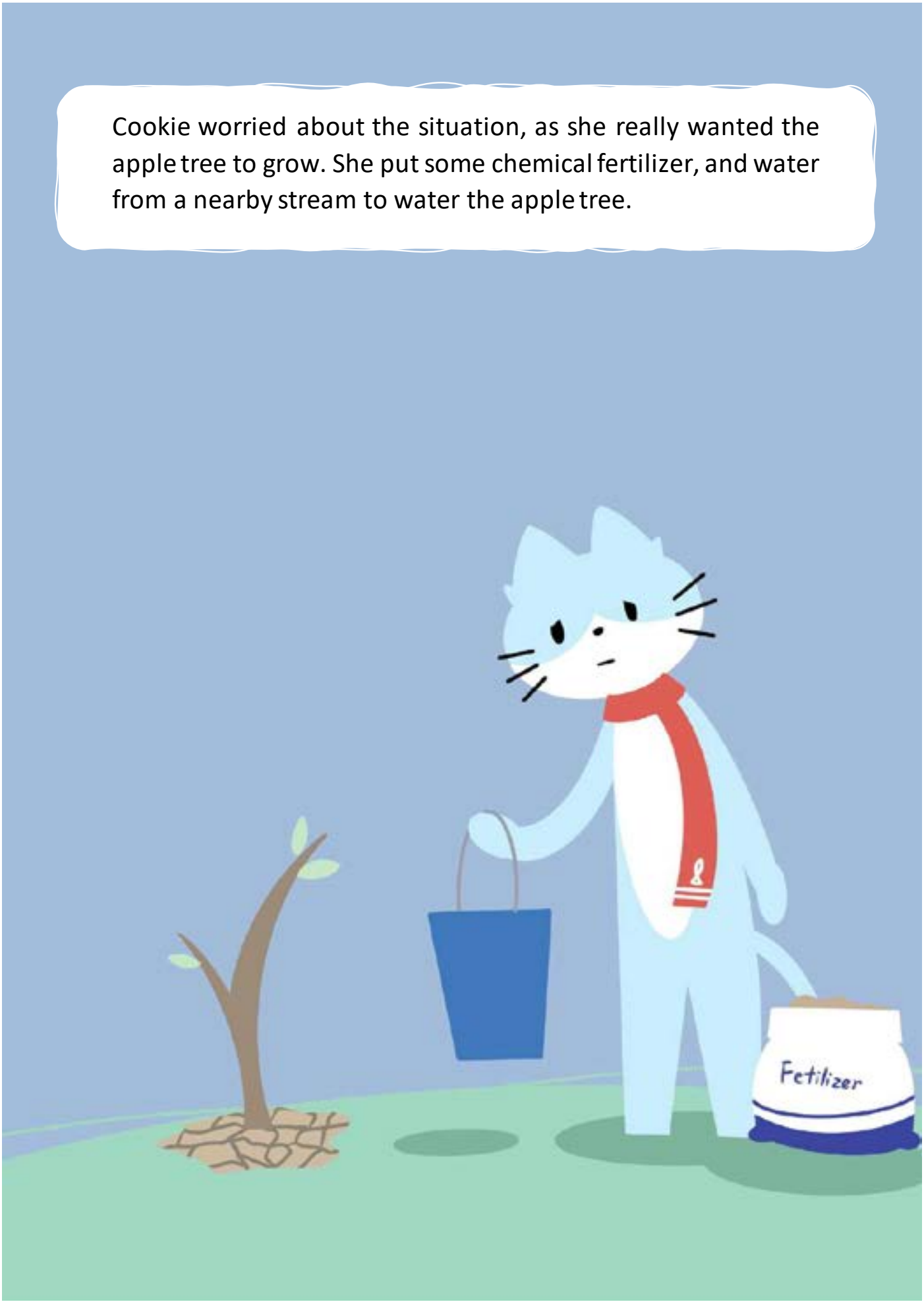
That is cookie's apple dream: she wants to plant a big apple tree.

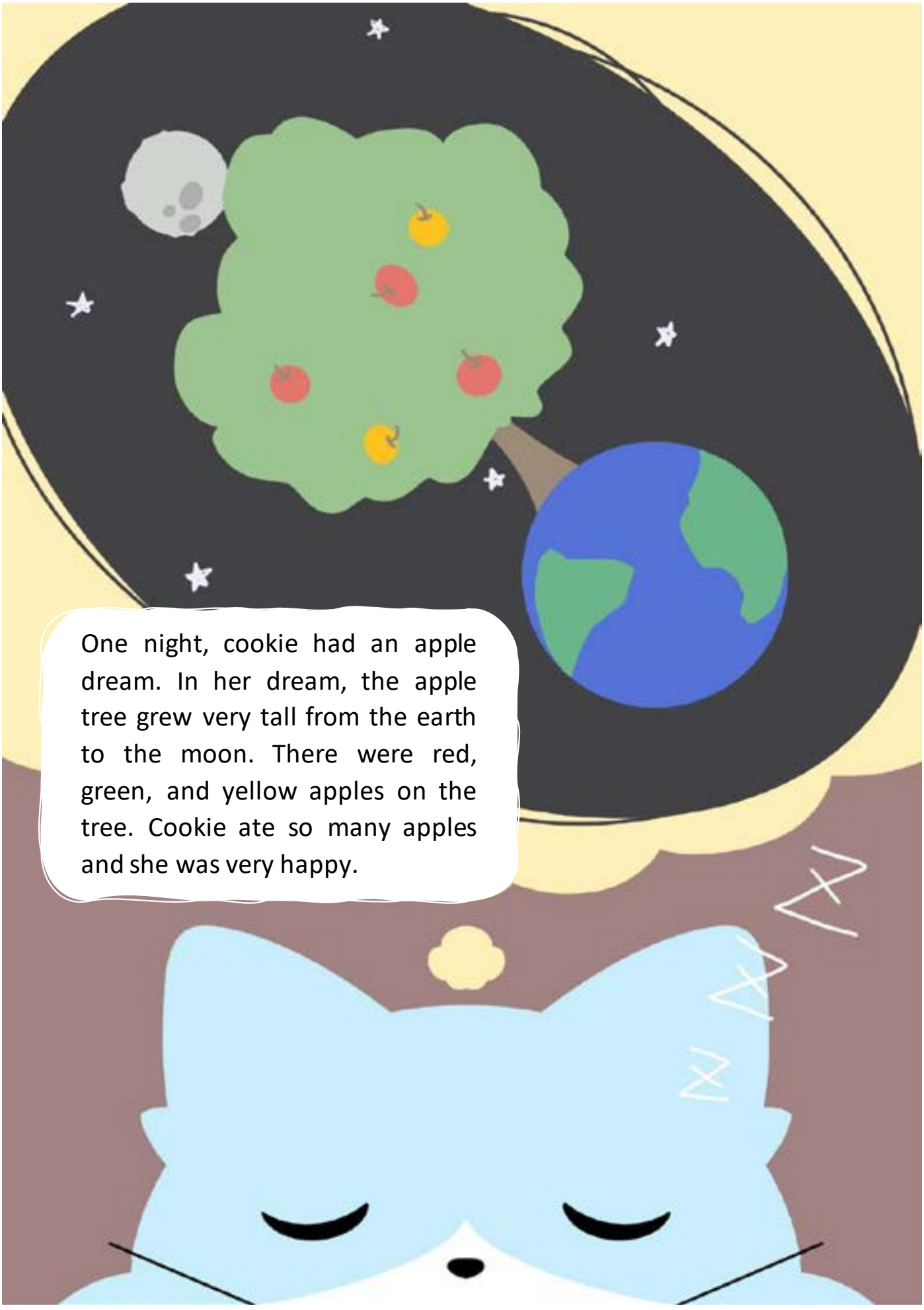
In spring, Cookie is excited to buy an apple tree from uncle giraffe's tree store. She has chosen a lively one with green leaves.

With the help from daddy and mommy, the apple tree was planted in the corner of their farm.

However, when they were planting the apple tree, Cookie found that the soil was very dry and looked white. The other plants also looked sickly.

Cookie worried about the situation, as she really wanted the apple tree to grow. She put some chemical fertilizer, and water from a nearby stream to water the apple tree.

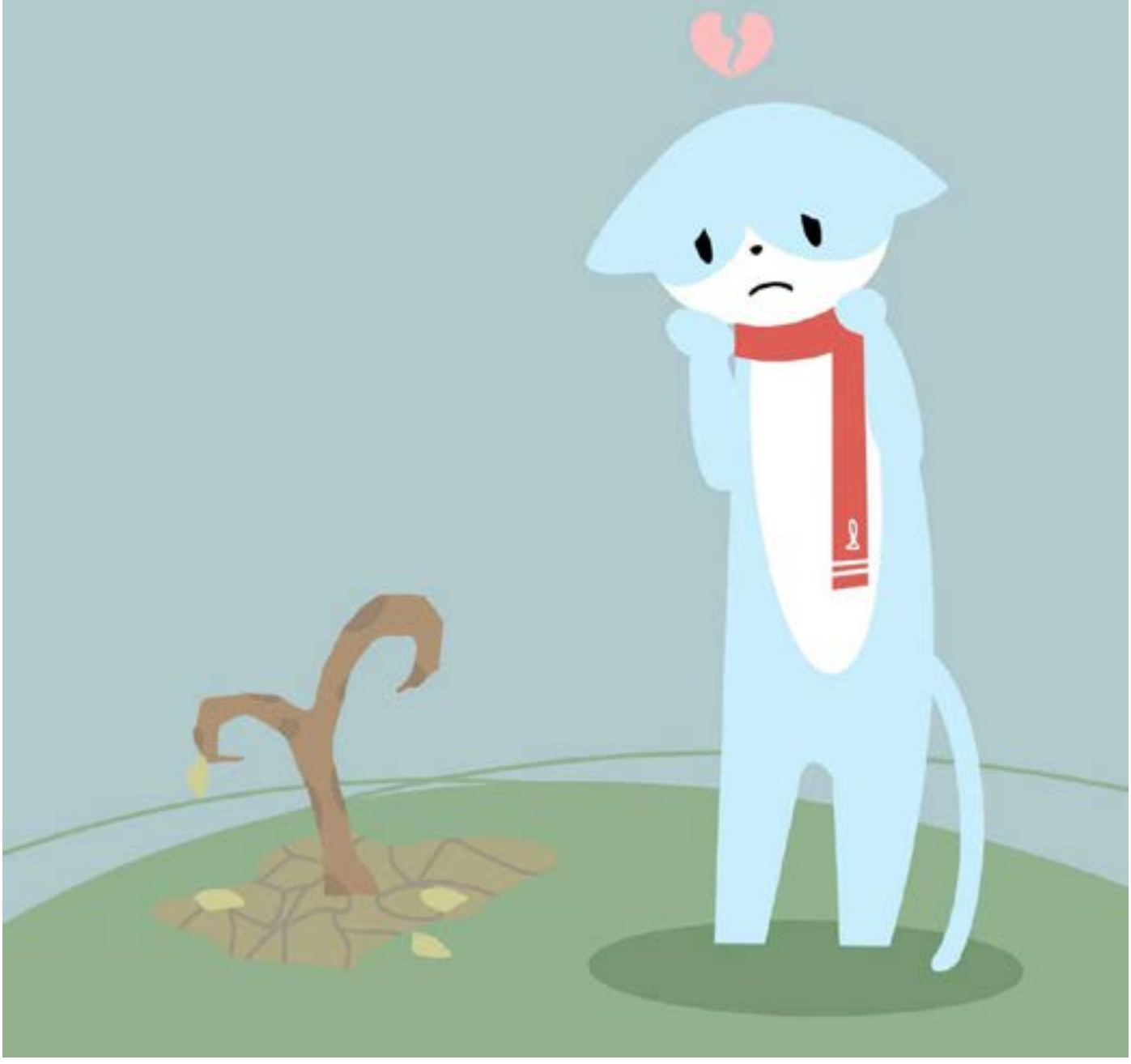



One night, cookie had an apple dream. In her dream, the apple tree grew very tall from the earth to the moon. There were red, green, and yellow apples on the tree. Cookie ate so many apples and she was very happy.

In the morning, cookie quickly woke up to check on the apple tree.

But when she arrived to the farm, the sight made her sad. The apple tree looked sick, and the leaves curly, dry and many fallen off.

Cookie wanted to save the apple tree and her apple dream. She went to explain the situation to her science teacher Elephant.



Teacher Elephant: Cookie, what you see in your farm is a perfect example of the effect of soil salinization on plant. If you want to save your apple tree, you need to save the soil first. Our soil is facing a salinization problem now.

Cookie: What do you mean by soil salinization?

Teacher Elephant: Soil salinization is when the soil contains excess salts such that it negatively affects soil productivity and plant growth[1].

Cookie: How does this happen?

Teacher elephant: Breeze from the ocean can transport salt to the land[2] or rising sea level can intrude into the land[3]. Because we live in a coastal area, these two might be possible.

Teacher elephant: Sometimes, wind-blown aeolian dust can be a source of salty soil[4]. Also, when you have salty underground water, it can rise to the land surface and make the soil saline[5]. All these are natural processes that make the soil saline. But humans can also cause the soil to be saline. As an assignment, find out how humans cause soil salination and how to prevent it.

Cookie discussed the problem with her friends.

Cookie: Hello friends! Do you know how humans can make the soil saline? I want to prevent it!

Fox: Hmm!!! I know that, in winter, people use salt to thaw the ice from the streets. This salt can enter and remain in our soil[6].

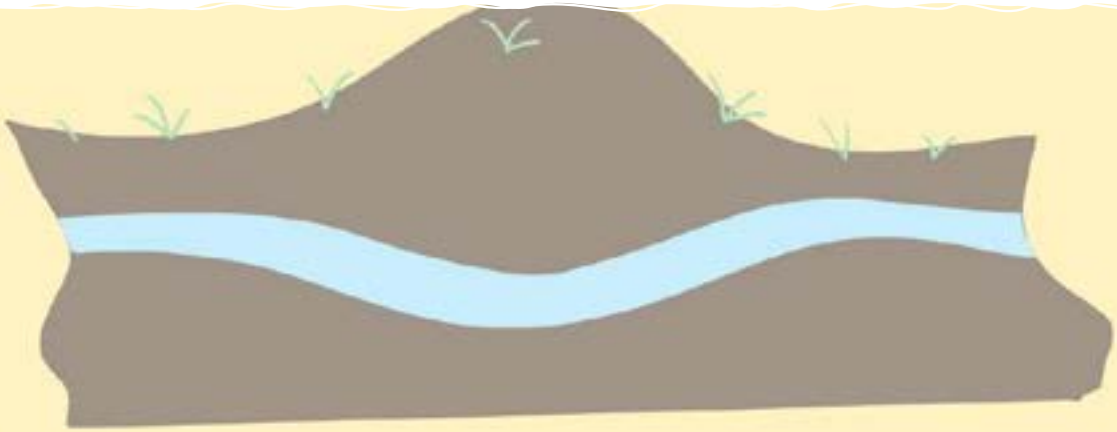
Rabbit: Chemical fertilizers are made in salt form, so when we apply to the soil, it can make the soil saline[7].

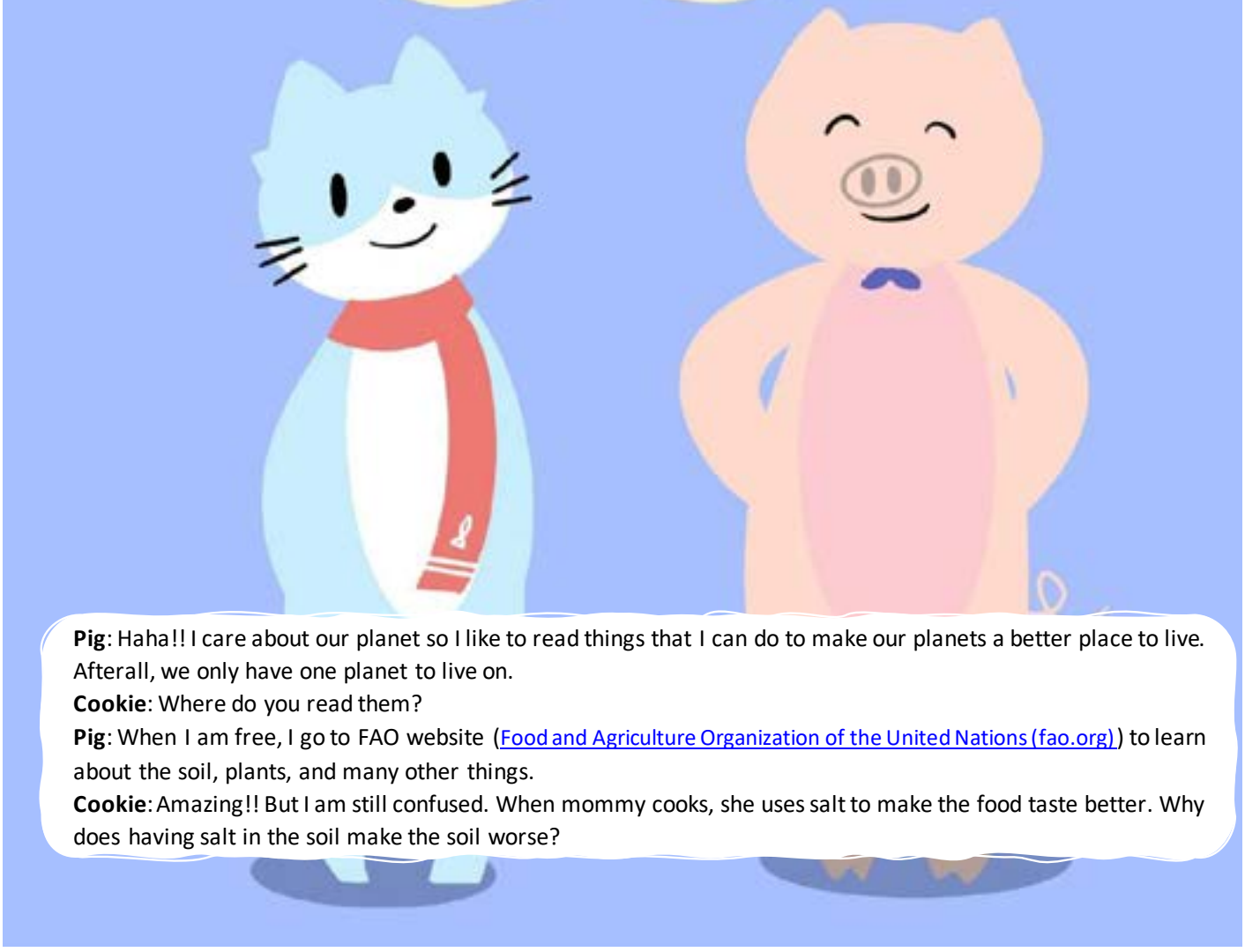
Raccoon: When we irrigate plants with waste water containing salt, this can also make the soil saline[8].

Pig: Cutting down deep-rooted trees can also cause soil salinity.
Cookie: How does cutting trees affect soil salinity?

Pig: Trees with big roots prevent underground water from rising to the soil surface. When the trees are removed, salty underground water easily rises to the soil surface to make it saline[9].

Earthworm: That is brilliant Pig. Where did you learn that?





Pig: Haha!! I care about our planet so I like to read things that I can do to make our planets a better place to live. Afterall, we only have one planet to live on.
Cookie: Where do you read them?
Pig: When I am free, I go to FAO website (Food and Agriculture Organization of the United Nations (fao.org)) to learn about the soil, plants, and many other things.
Cookie: Amazing!! But I am still confused. When mommy cooks, she uses salt to make the food taste better. Why does having salt in the soil make the soil worse?

Earthworm: Cookie! what tastes good for humans is not always good for the soil. Excessive salts may not be good for the soil. Soil salination changes the soil ion balance, destroys the soil structure, makes the soil friable and dry[10]. Many microorganisms are unable to live in these saline conditions[11]. Do you realise that even me (earthworm), I changed my house from the farm to live in the compost nearby? Too much salt in the soil makes me sick[12]. Not only me, but plants also find it hard to live in such soil and can easily dehydrate[13]. As a result, the soil will have less productivity and affect the livelihood, ecosystems, and economy of the people. I think Cookie, you did all the things to make the soil worse, that's why your apple tree can't grow.

Cookie: What can I do to make my apple grow?

Pig: Okay friends, let us go to the FAO website to read more about how to 'halt soil salinization and boost soil productivity'.

Cookie and her friends research on ways to repair saline soils and found the following methods:

- Replace chemical fertilizer with organic fertilizer
- Use clean water to irrigate the farm.
- Plant trees in the land to keep the water table low
- Add gypsum to the saline soils
- Plant salt tolerant species
- If the salinity is in a small area, flush with lots of water
- Improve the soil structure by adding biochar
- Use cyanobacteria or salt tolerant bacteria as an inoculant plant growth

Cookie: We have so many options to choose from. Which one can we do now to save my apple tree?

Dog: Sure!!! The first one says we should replace chemical fertilizer with organic fertilizer.

Cookie: Isn't organic fertilizer very expensive?

Dog: No. When you buy and use cheap chemical fertilizer, you will spend more money again to repair the soil when it becomes saline. But if you use organic fertilizer, you will not have the extra cost of repairing the soil. So organic fertilizer is cheaper in the long term compared to chemical fertilizer.

Rabbit: You explain it so well Dog, but you can make compost at home and apply to the soil as well. This is super cheap and easy to do.

Earthworm: Yes!!! Adding organic fertilizer or compost is similar to adding biochar to the soil. They both can attach to the salt ions in the soil and make it unavailable to the plant. So the plant will grow well and not feel the salinity effect.

Fox: Another option is to prevent salt from building up in the soil by irrigating with good quality water. It is better to prevent than to repair. So, we should make sure we avoid salt from building up in the soil.

Pig: Good point Fox. Prevention is always better. Also, there is water scarcity around the world so we should use water wisely.

Cookie: I will not waste water again. I will tell my father to do rain harvesting so that he can use it to irrigate his farm.


Raccoon: How about planting trees in the farm to keep the salty water table low?
Pig: Amazing idea Raccoon. I read in the FAO article that we can combine food crops and trees in the same piece of land. It is called agroforestry[14].
Dog: I think Cookie can tell his dad to practice agroforestry. It will help to improve the soil in his farm. He can also plant crops that are tolerant to salinity, so that his farm will still maintain productivity, and there will be lots of food to sell.
Bee: Do you know that cyanobacteria and halophiles are excellent microorganisms that can help plants to grow in saline soils? We can apply cyanobacteria when we are planting seeds in the farm. The cyanobacteria will help the plants to grow well and absorb some salinity[15].
Cookie: Thank you guys! I will practice all of them.

With these efforts from Cookie, the apple tree and farm gradually recovered. In the second autumn, cookie harvested many sweet apples.

Now Cookie's apple dream comes true.

Let us ***"Halt soil salinization, Boost soil productivity"***

Activity

We collected some children's paintings from different places. Their works showed cares about salt-affected soils and best wishes to future.

Mark Bogdanović-Muñoz, Y 5, Australia | Kevin Chen, Y 10, USA | Xiaoxuan Jiang, Y 8, China

Samuel Kojo Prah Gaisie, Y 11, Australia | Anne Chen, Y 5, USA | Luqingqing Wang, Y 7, China

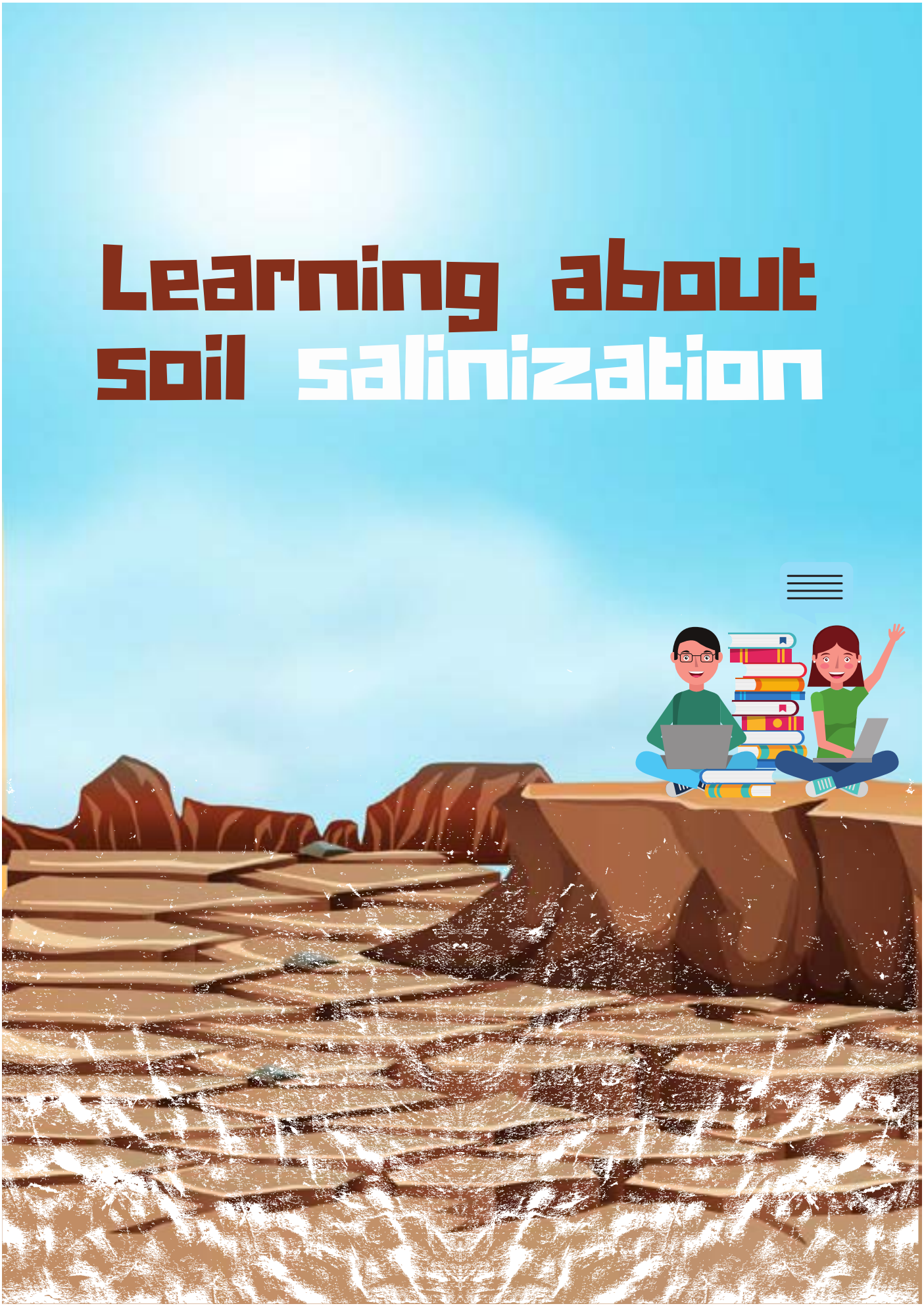
Now, it is your time to draw a creative painting about ***"Halting soil salinization, Boosting soil productivity"***

Learning about soil salinization

Author

Juan Camilo Fontalvo Buelvas is 29 years old and was born in Barranquilla, Colombia, but currently lives in Xalapa, Mexico. He is an academic bachelor with an emphasis in education and pedagogy by the Escuela Normal Superior de Corozal of Sucre, Colombia. He has a degree in biology from Veracruzana University, Mexico, and from the University of Sucre, Colombia. He also is a Master in Environmental Management for Sustainability with an honorary mention from the Veracruzana University, Mexico. During this postgraduate course, he was able to link his pedagogical training with his biology career through ecopedagogy and agroecology, thanks to the Agroecological Garden, a classroom-laboratory within the Faculty of Biology of the Veracruzana University. The most important thing about this booklet is the target audience (children and young people). With this material, he hopes the little ones will be passionate about life under our feet and inspired to discover sustainable solutions for soil salinization.

Learning about soil salinization



To start

Soil is an important component that hosts and supports a wide variety of natural ecosystems and managed agroecosystems. Soil is essential not only for the conservation of vegetation and animals, but also for the subsistence of human populations, as most of the food we consume daily depends on the soil. Unfortunately, today the soil faces many problems that put its health and that of agricultural systems at risk.[1]

One of these serious problems is soil salinization, a phenomenon that occurs when soil accumulates water-soluble salts excessively. On our planet there are more than 833 million hectares of soils affected by salinity; about 8.7% of the Earth's surface. These areas that have been expanding in recent years, can be found in naturally arid or semi-arid environments in continents such as Africa and Asia, but also in some areas of Latin America.[2]

Other recent figures show that between 20% and 50% of cultivated soils on all continents are being drastically affected by salinity. This means that around 1.5 billion people around the world have difficulty growing food because of the severe degradation of the soil. But what impacts does salinization have on soil? How does this silent enemy affect ecosystems and human well-being? How could we solve this? These and other questions we will try to solve in this booklet.

"Halt soil salinization, boost soil productivity"

1 Wall, Nielsen and Six (2015)
2 FAO (2020)

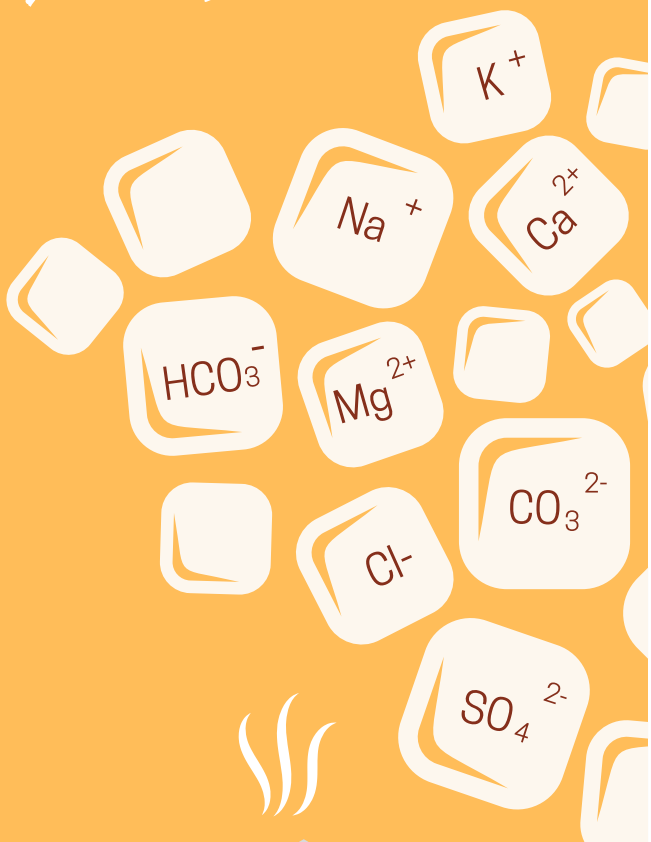
Primary and secondary salinization [3]

Soil salinization occurs when there is a gradual increase, gain, or accumulation of soluble salts in the soil. These salts are potassium, magnesium, calcium, chlorides, sulphates, carbonates, bicarbonates and sodium. When it comes to the increase in the percentage of sodium there is talk of **sodification** of the soil.

Primary or natural salinization involves the accumulation of salt due to a high salt content in the soil itself or in groundwater. Secondary salinization is caused when people mishandle the soil.

3 Singh (2021)

Discover:
What salt does each symbol correspond to?

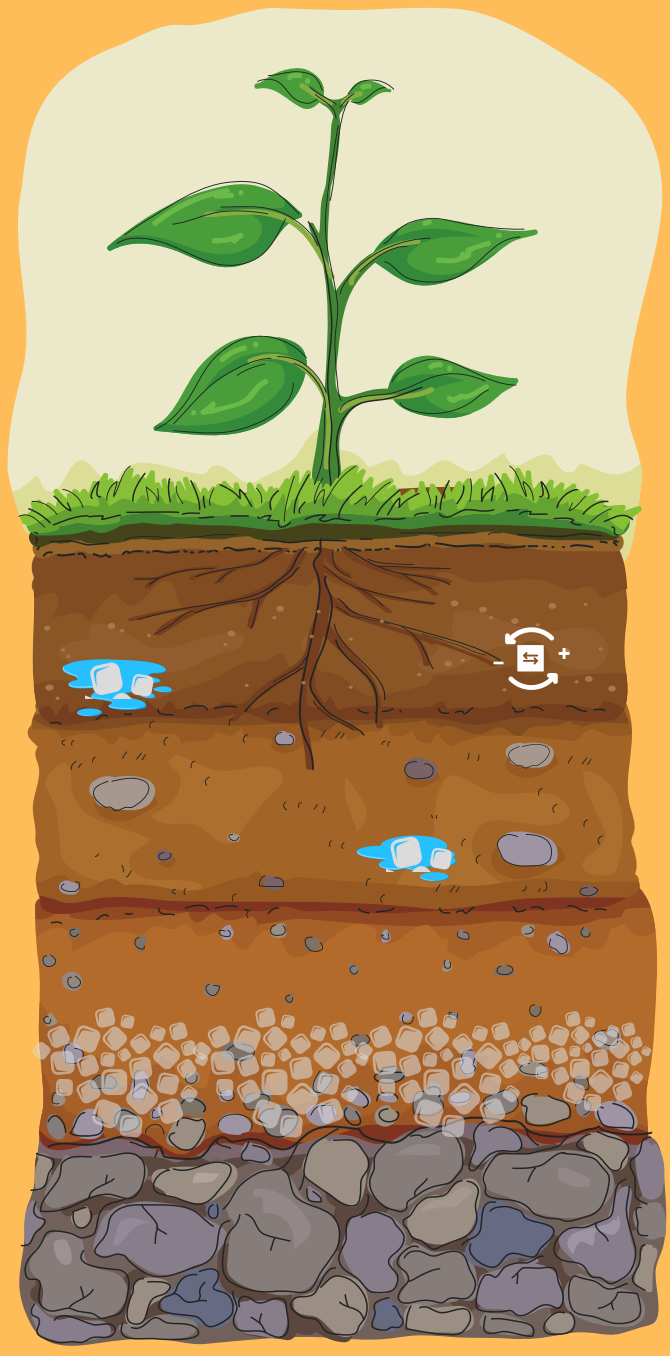


State of salts in soil[4]

Salts can be found in different states in the soil:

- Precipitated in the form of crystals
- Dissolved in soil water
- Retained in plant uptake change complex

Find the three states of salts in the ground



These three states are highly variable and depend on various factors such as climate, seasons, rainfall, evapotranspiration, land use and management. During the dry season, the number of dissolved salts decreases, while during the wet season, the number of precipitated and retained salts decreases. The balance of these three states depends on the structure of the soil, its fertility and health.

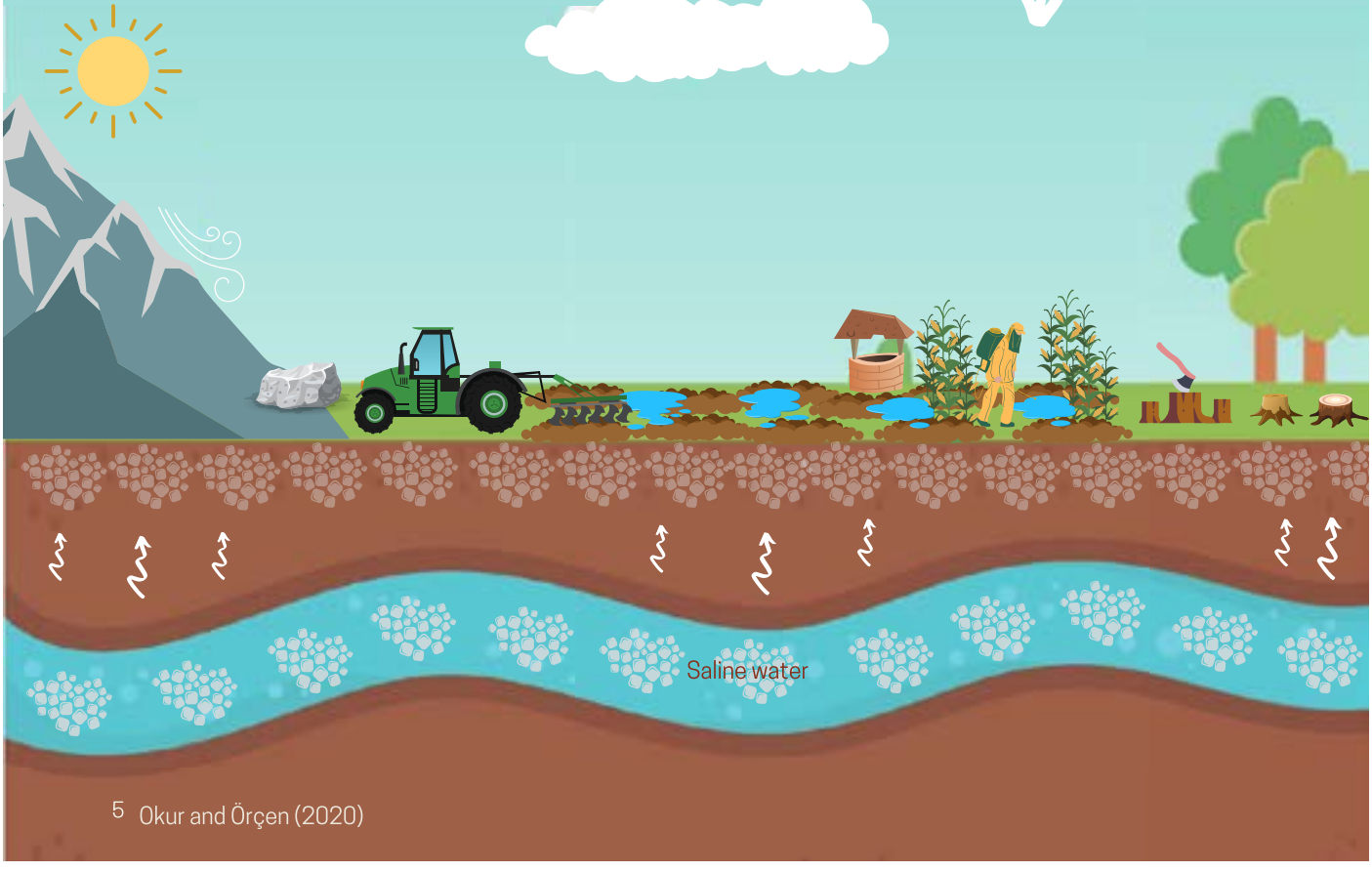
4 Pickering (1985)

Main causes of soil salinization[5]

The soil can be salinized and/or sodified due to natural factors such as the material of the mother rock that is under the ground or in a nearby area, the topography, the climate, the wind and the type of vegetation. But also by the infiltration of groundwater into areas below sea level. In addition, there are some human activities that accelerate soil salinization:

- Excess soil irrigation with poorly drained irrigation systems or brackish water irrigation from saline aquifers, sewage or industrial by-products
- Deep or conventional soil tillage
- Deforestation or loss of vegetation cover
- Excessive groundwater abstraction in coastal areas
- Overuse of fertilizers and other chemical inputs
- Overexploitation of land for agricultural activities

Note in the illustration the inappropriate practices that cause soil salinization



5 Okur and Örçen (2020)

Environmental impacts of soil salinization[6]

Soils with high content of soluble salts and/or high amounts of sodium ions, have difficulties in the exchange of water and nutrients with the roots of plants. Consequently, most plants that are not tolerant to salt die, as well as most animals that live in the soil, being replaced by other plants and animals that adapt to these conditions. In this way, the soil degrades rapidly, losing structure and fertility; thus the ecosystems are transformed into arid and desert zones, an issue that increases global warming.

6 Teh and Koh (2016)

Soil salinization and food production

The amount of world agricultural land destroyed by salt accumulation each year is estimated to be 10 million ha.[7] Agricultural soils affected by salt accumulation have little capacity to produce food profitably. Salts make deeper layers of soil more impermeable, which increases compaction and decreases water infiltration. This type of saline and sodium soils are more exposed to water and wind erosion, thus progressively losing nutrients and fertility until their degradation, which causes the soil to be unsuitable for agriculture. Most crops fail to tolerate high levels of salt, saline stress causes nutritional imbalance, as well as reduced growth and development of plants, so they end up dying from toxicity. These processes drastically affect food production, putting food security in rural and urban communities at risk.[8]

7 Pimentel *et al.*, (2004)
8 Piedra and Cepero (2013)

Socio-economic impacts of soil salinization[9]

Generally, when the soils of agricultural farms undergo salinization and/or sodification, farmers increase the use of chemical fertilizers. This affects the economy of peasant families who, without land or money, are forced to abandon the fields and productive activities. As a result, rural communities migrate to urban areas in search of new livelihoods, leading to land encroachment and urban sprawl. This situation has serious consequences for the well-being of communities as food shortages, hunger and poverty increase.

9 Salvati and Ferrara (2015)

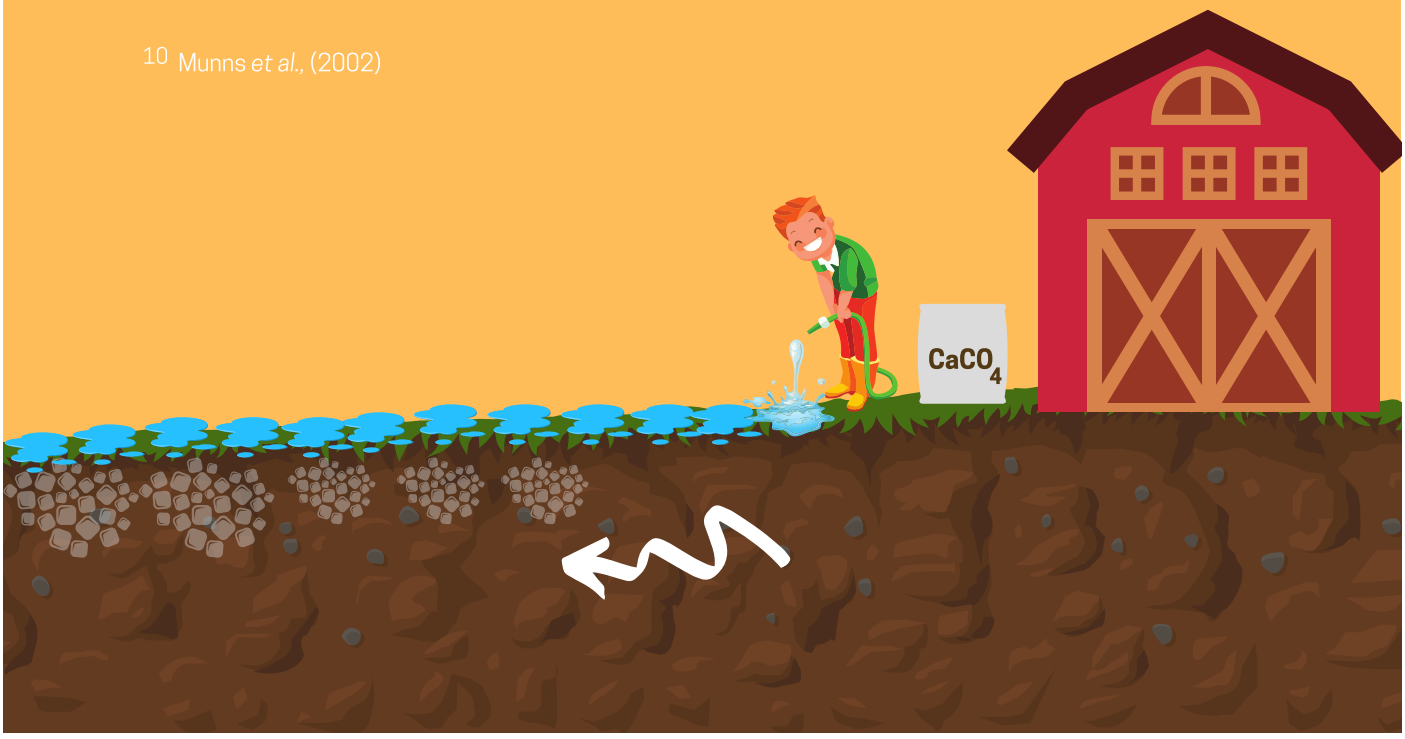
Sustainable Management of salt-affected soils

Washing soil [10]

Soil salinity and sodicity are problems too difficult to overcome, requiring salt washing from the root zone. However, in addition to being slow and expensive, the process requires large quantities of quality water and effective soil drainage. It is not always easy to obtain enough quality water, because the possible water sources next to the soils to be treated may already themselves be highly saline.

In case the sodic soils, the reclamation involves substituting sodium in the soil with calcium ions, through applying large quantities of gypsum. Gypsum, when slowly mixed with water, releases calcium ions, which replace sodium ions from the soil into the downward moving water. Sulfuric acid and elemental sulfur can also be used as alternatives to gypsum.

[10] Munns *et al.*, (2002)



Sustainable Management of salt-affected soils

Correct fertilization

Crop fertilization is one of the sources of salinization of soils. To reduce this negative impact, the fertilizer characteristics and the method of fertilizer application. Excessive nutrient applications must be avoided, and high-purity, chloride-free, low-saline fertilizers should be selected. The application of fertilizers through irrigation water (fertigation) can reduce soil salinization and mitigate salt stress effects because it improves the efficiency of fertilizer use, increases nutrient availability and timing of application, and the concentration of fertilizers are easily controlled.[11]

Humic substances and biofertilizers can ameliorate the deleterious effects of salt stress by increasing root growth, improving uptake, thus inducing salt tolerance.[12]

[11] Machado and Serralheiro (2017)

[12] Ouni *et al.*, (2014)

Sustainable Management of salt-affected soils

Efficient irrigation and drainage

Irrigation method, irrigation scheduling and artificial drainage can prevent and mitigate the effects of soil and water salinity. For better salinity management is advisable to use irrigation methods such as surface drip irrigation and subsurface drip irrigation. An appropriate irrigation scheduling with these methods can also reduce the effects of salinity by continuously maintaining moist soil around plant roots and providing steady washing of salt to the edge of the wetted zone. If soil drainage is poor and the water table is shallow, it is recommended an artificial drainage system must be installed.[13]

In addition, to ensure long-term land use with irrigated vegetable crops, it is necessary to do a maintenance leaching. The volume of water applied with irrigation must include a water amount that drains down the root zone, which is in addition to the amount required for normal irrigation.[14]

[13] Malash *et al.*, (2008)
[14] Letey *et al.*, (2011)

Sustainable Management of salt-affected soils

Genetic improvement

Salinity tolerance is a desirable attribute of plants that are sought in laboratories through genetic improvement. This is achieved by the selection and recombination of species to obtain such a character. The success of these processes depends on the availability and extent of genetic variability within the species concerned. Genetic improvement becomes a tool that offers an increase both in the recovery of underutilized areas, and in yields in those areas where salinity is a limiting factor of agricultural production. To do this, many scientists are working to obtain varieties resistant to salinized soils. Among these, the incorporation of genes from tolerant wild parents, the domestication of wild halophiles and the identification of traits related to high tolerance are of particular interest. The intention is to produce these varieties in laboratories and then share them with farmers to improve productivity in the field. [15]

[15] González *et al.*, (2000)

To finish

So far we have learned a little about the salinization and sodification of soils, a complex problem that is increasing the desertification of large agricultural and non-agricultural areas in different parts of the world. Undoubtedly, as soil salinization increases, so do environmental, social, and economic impacts. Therefore, this issue should interest us all because it affects not only the biodiversity of our ecosystems, but also the sustainable production of food. We must understand as humanity that we depend heavily on the soil to eat daily and that the quality of the soil conditions the quantity and availability of food in our dishes.

Fortunately, there are already some technical solutions for sustainable soil management, which must be socialized with people in the countryside to be implemented. However, less costly solutions need to be sought to halt soil salinization and increase soil productivity. It is important that we continue to learn about the soil a wonderful ecosystem that offers multiple environmental services, but that currently suffers serious degradation problems.

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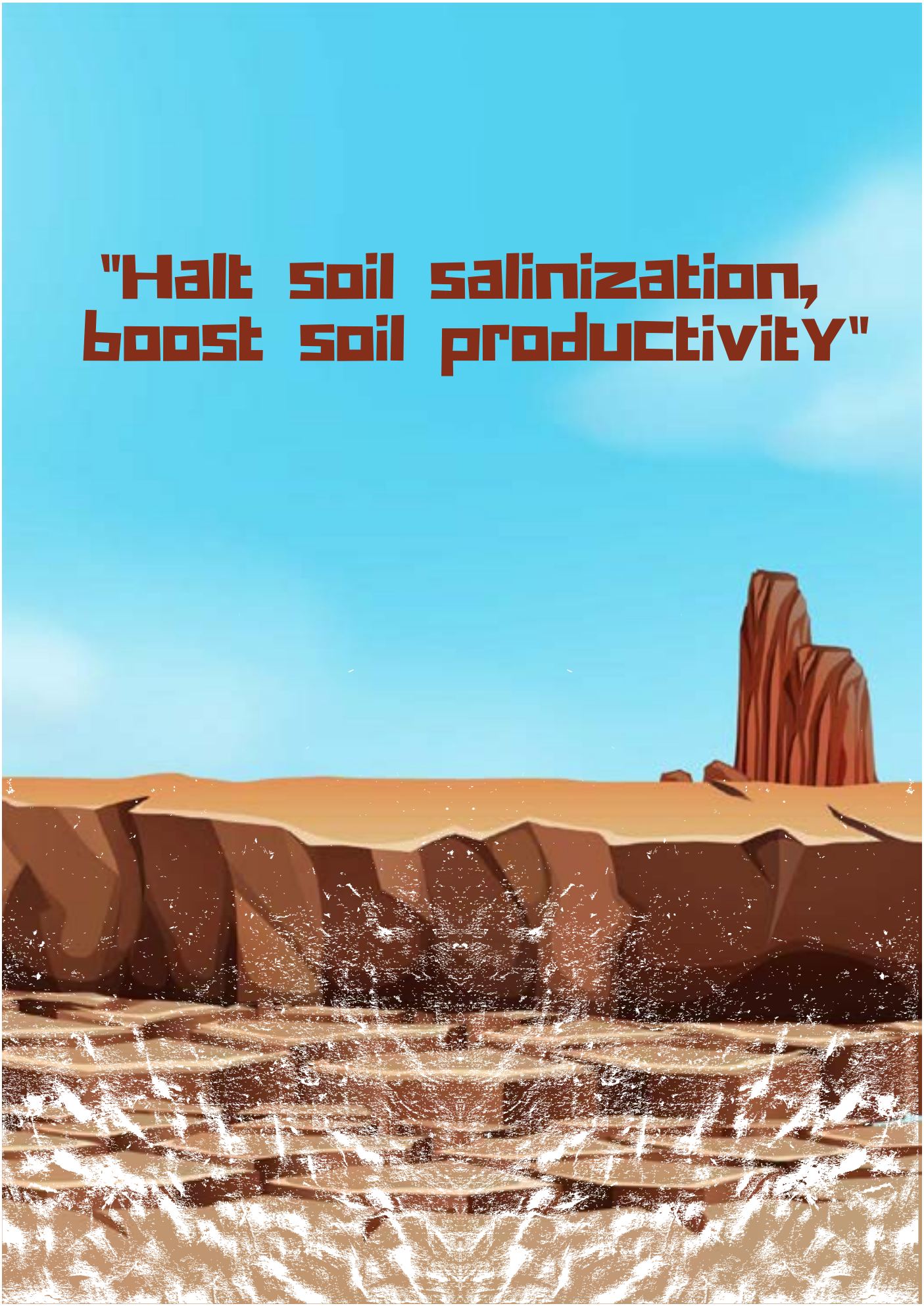
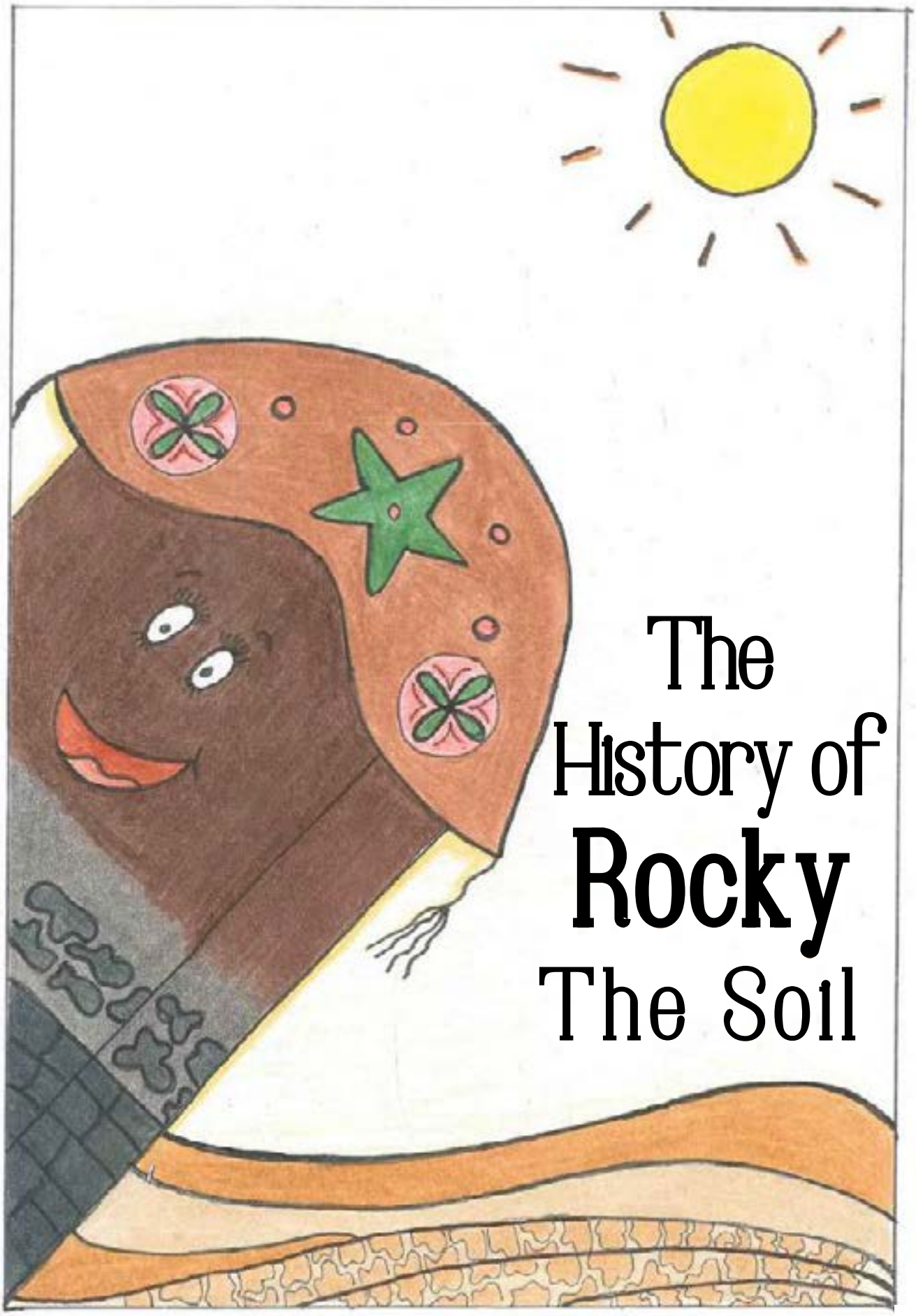

"Halt soil salinization,
boost soil productivity"

History of Rocky
The Soil

Authors

Bruna Vicente wrote and designed this book. She graduated in Agronomy from the Federal University of Fronteira Sul - Campus Cerro Largo, and is currently a Master's student in Soil Science at the Graduate Program (PPGS) of the Federal University of Santa Maria, Brazil.

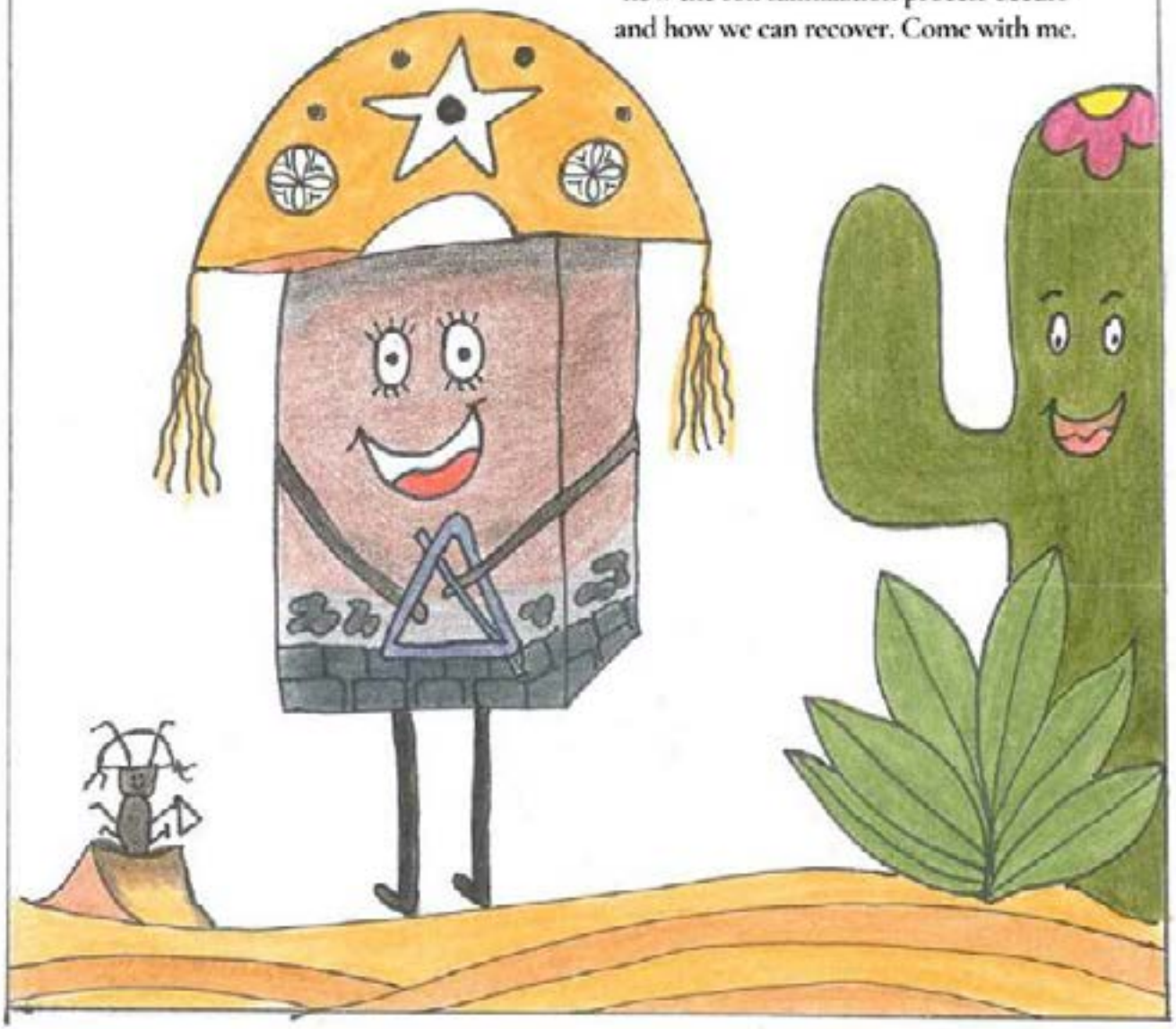
She had the support and review of **Douglas Rodrigo Kaiser**, professor at the Federal University of Fronteira Sul - Campus Cerro Largo and a Doctor in Soil Science from the Federal University of Santa Maria.

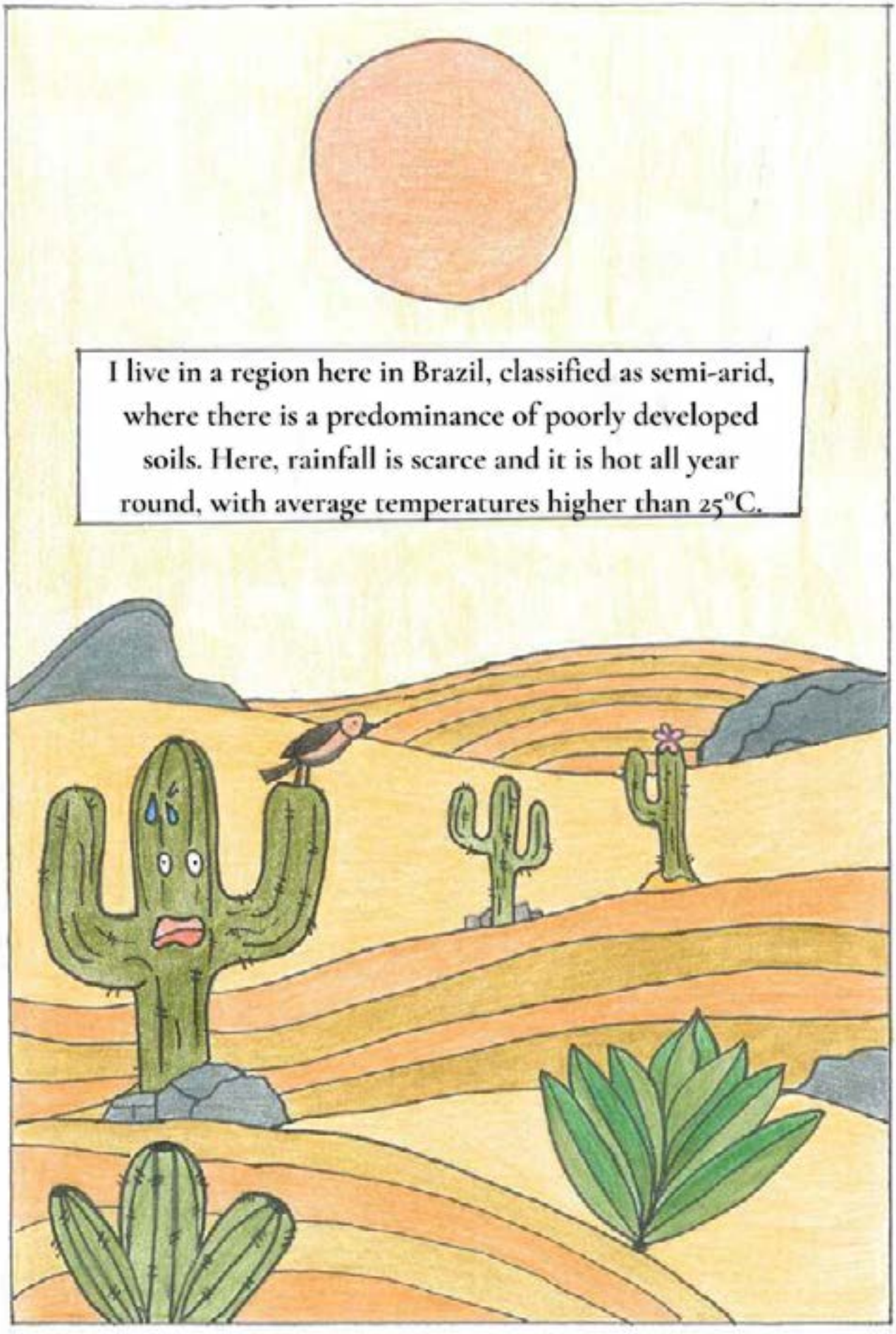

The
History of
Rocky
The Soil

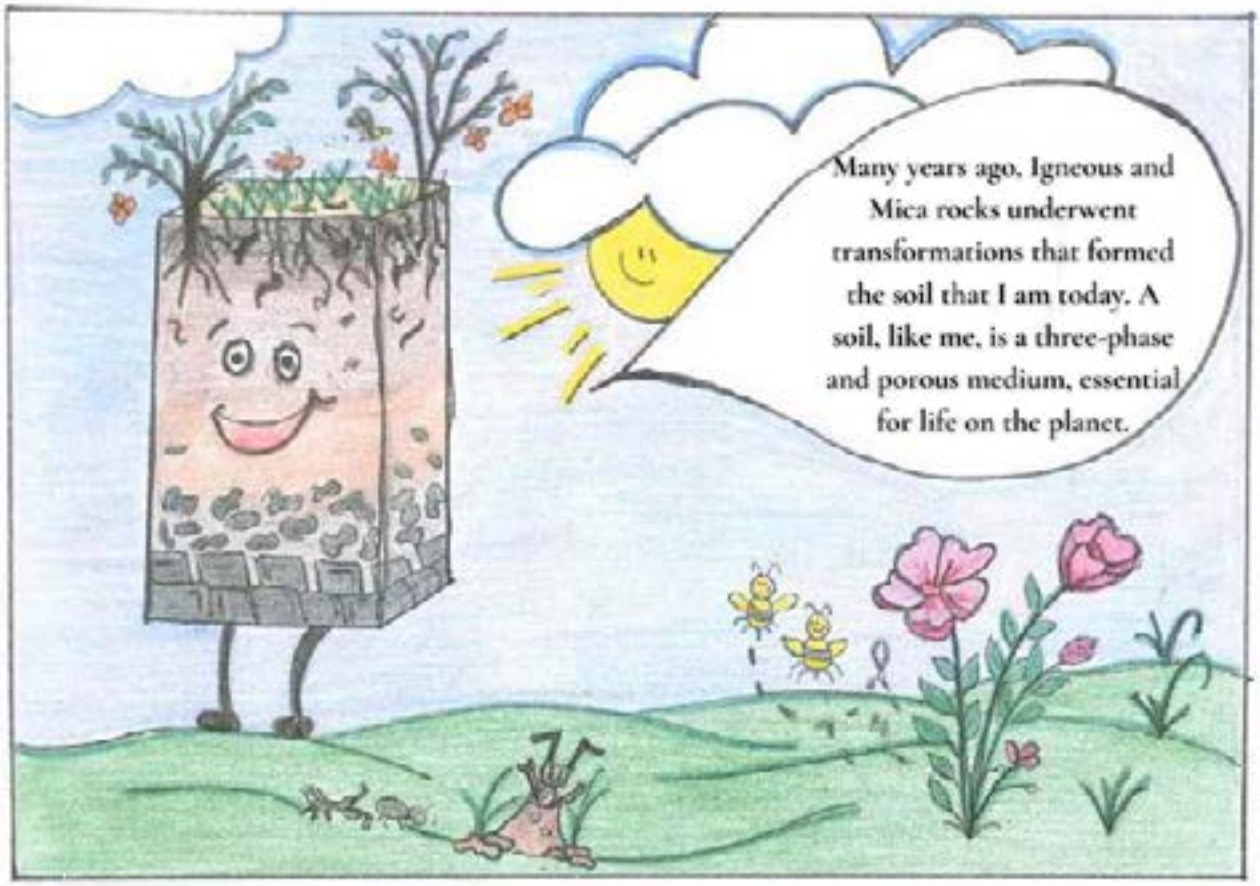
Hey guys! My name is Rocky. I am a soil belonging to the Luvisols class, originated from rocks such as gneisses, mica schists and limestones. Soils like me occupy more than 80% of northeastern Brazil, where I live.

The soils here in the Northeast undergo a degradation process called Salinization, when the levels of salts such as Sodium, Chlorine, Calcium and Magnesium are too high, causing problems with clogging of pores and making the soils poor. Human beings are overexploiting my resources and mishandling me and my siblings.

I will explain to you a little of my history, how the soil salinization process occurs and how we can recover. Come with me.



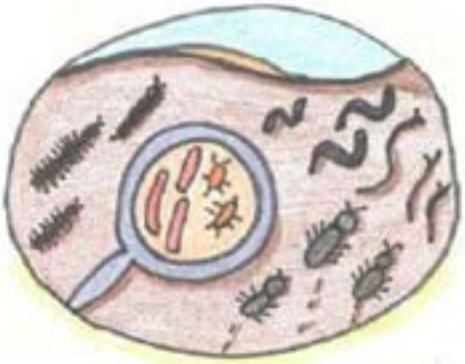

I live in a region here in Brazil, classified as semi-arid, where there is a predominance of poorly developed soils. Here, rainfall is scarce and it is hot all year round, with average temperatures higher than 25°C.


Many years ago, Igneous and Mica rocks underwent transformations that formed the soil that I am today. A soil, like me, is a three-phase and porous medium, essential for life on the planet.

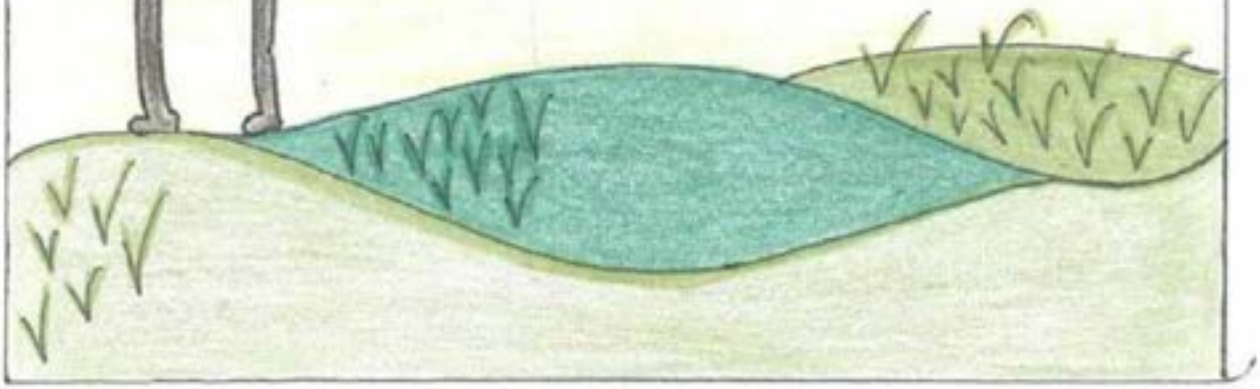

The transformations are called weathering, and they occur slowly over the years.

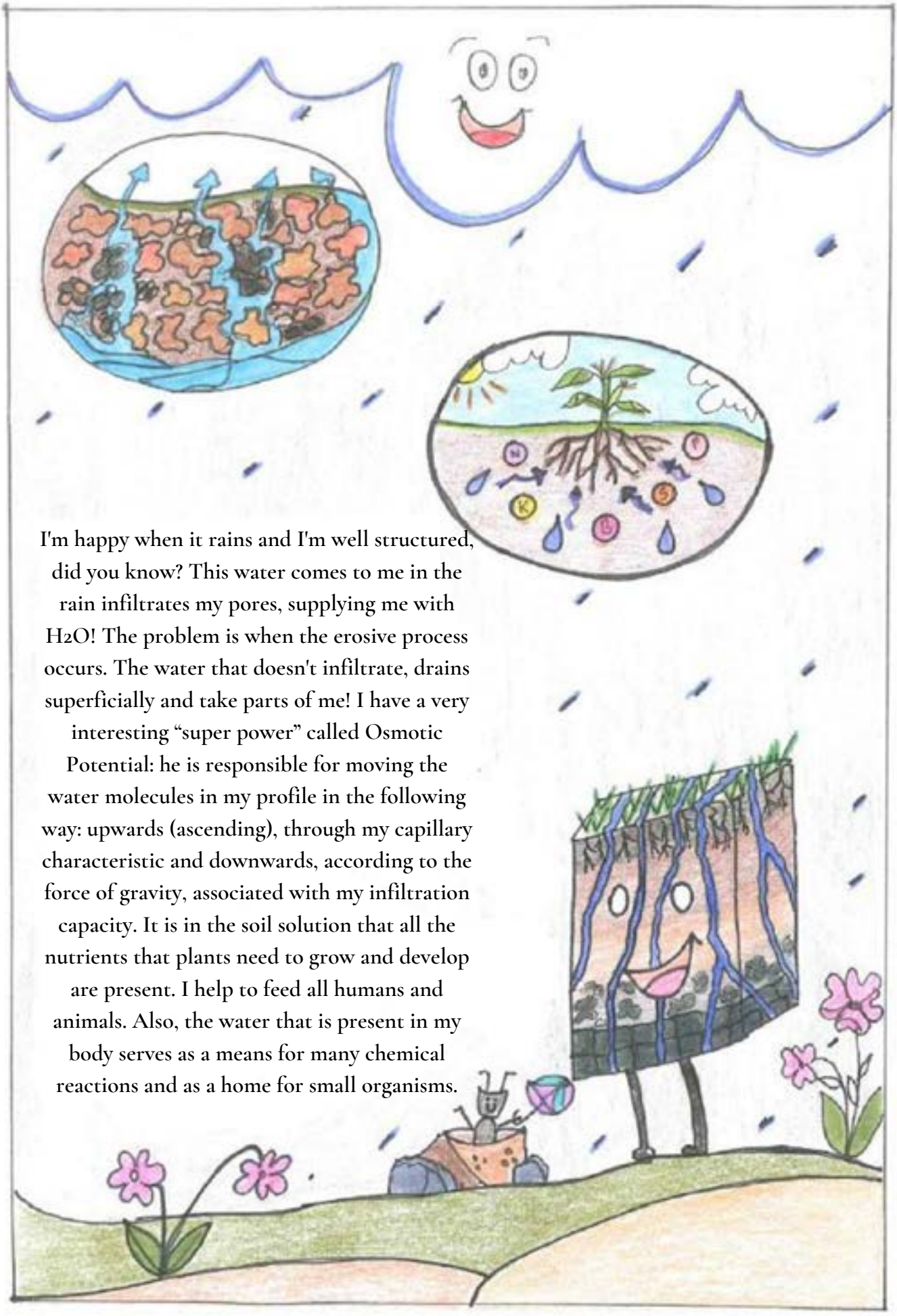

I was just a tiny rock that with variations in temperature, rain and microorganisms I was transformed.


This weathering can be biological, physical or chemical.
NO
NO



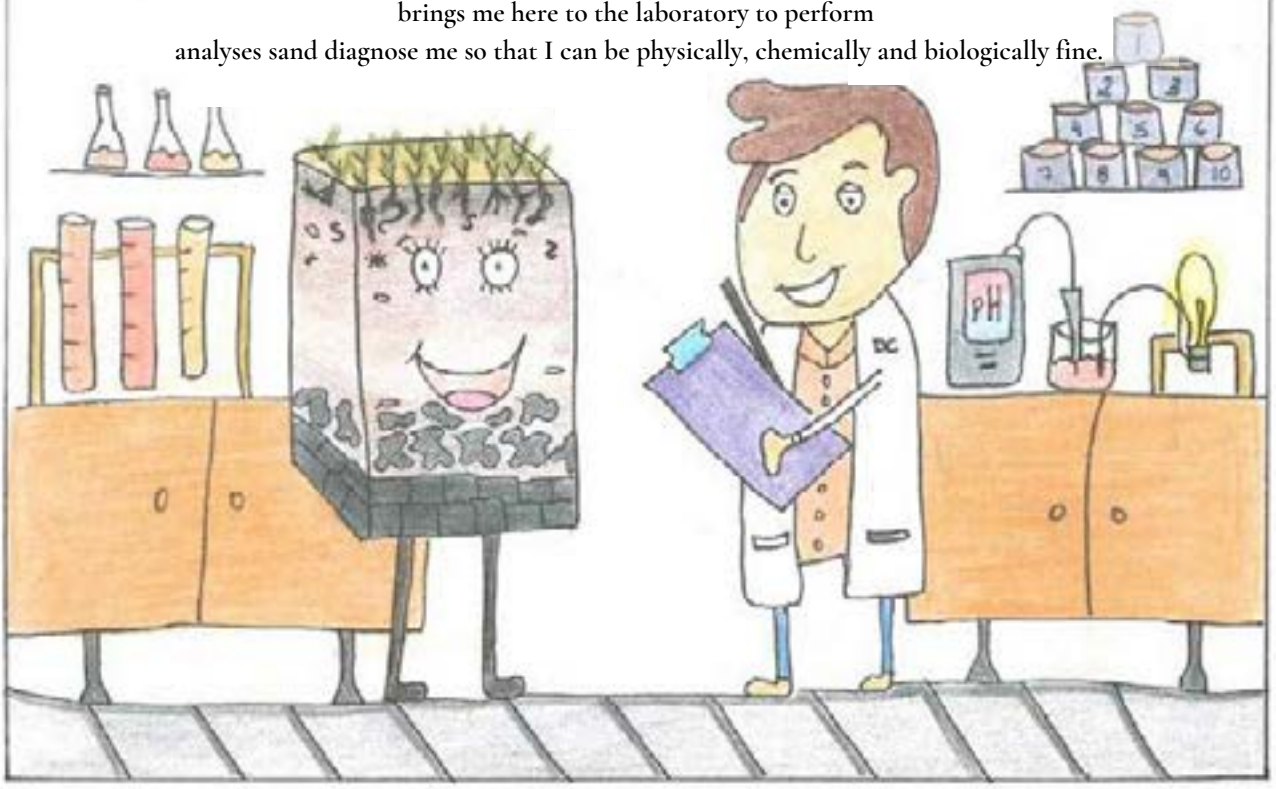
I have many functions, such as serving as a substrate for food production, providing biomass for animals and recycling nutrients, also serving to carry out the drainage of rainwater. Soil is also home to many microorganisms and insects.

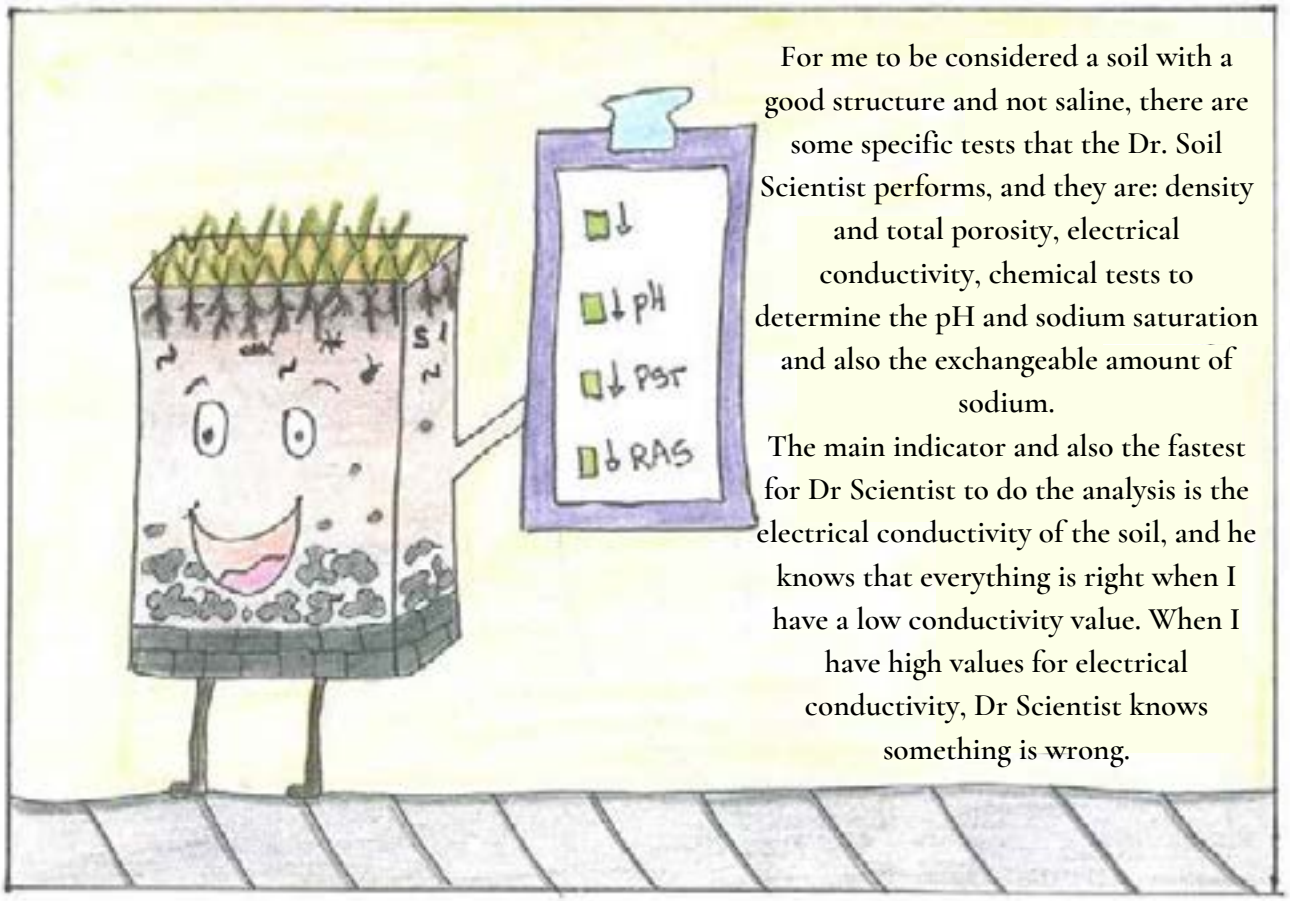




I'm happy when it rains and I'm well structured, did you know? This water comes to me in the rain infiltrates my pores, supplying me with H_2O! The problem is when the erosive process occurs. The water that doesn't infiltrate, drains superficially and take parts of me! I have a very interesting "super power" called Osmotic Potential: he is responsible for moving the water molecules in my profile in the following way: upwards (ascending), through my capillary characteristic and downwards, according to the force of gravity, associated with my infiltration capacity. It is in the soil solution that all the nutrients that plants need to grow and develop are present. I help to feed all humans and animals. Also, the water that is present in my body serves as a means for many chemical reactions and as a home for small organisms.

A properly managed soil results in a healthy soil that is very important for a good food production in a sustainable way. The soil management conditions in the region where I live are more delicate, because the environmental conditions make the soils here more prone to degradation. As it is essential to monitor these soils, mr. Soil Scientist brings me here to the laboratory to perform
analyses sand diagnose me so that I can be physically, chemically and biologically fine.

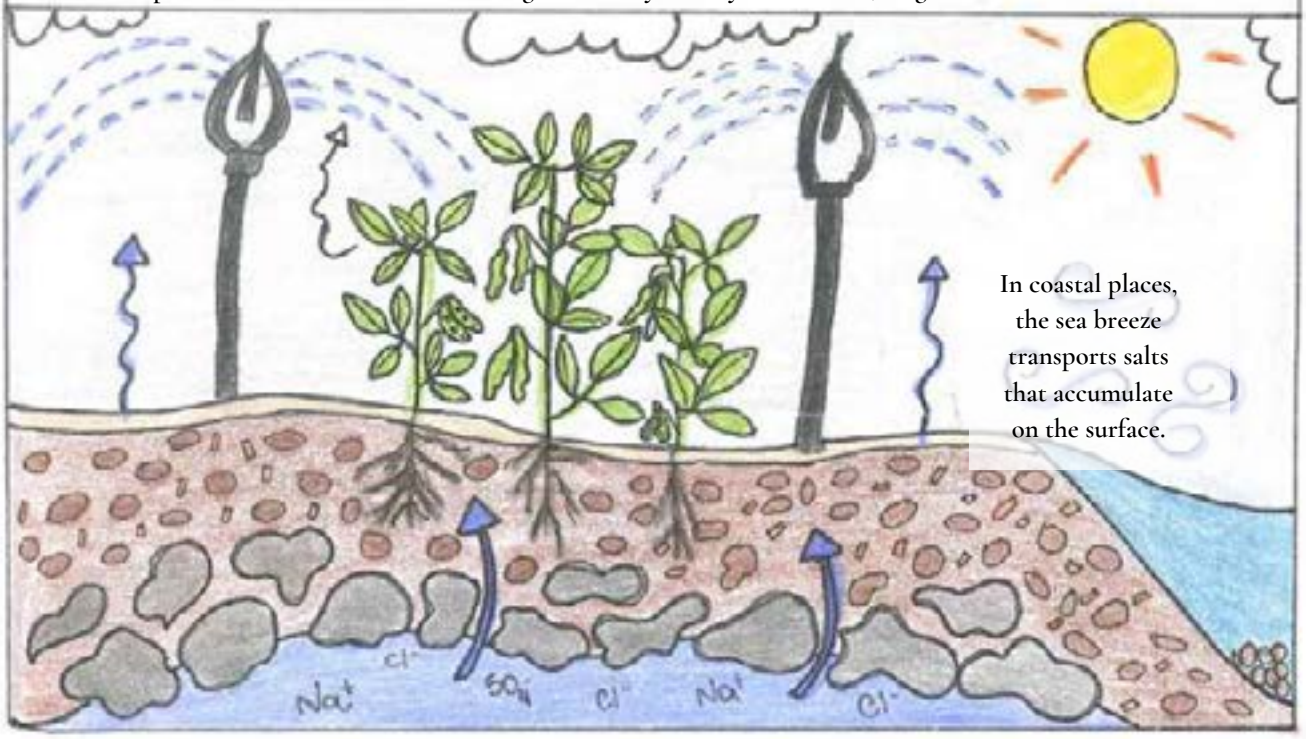


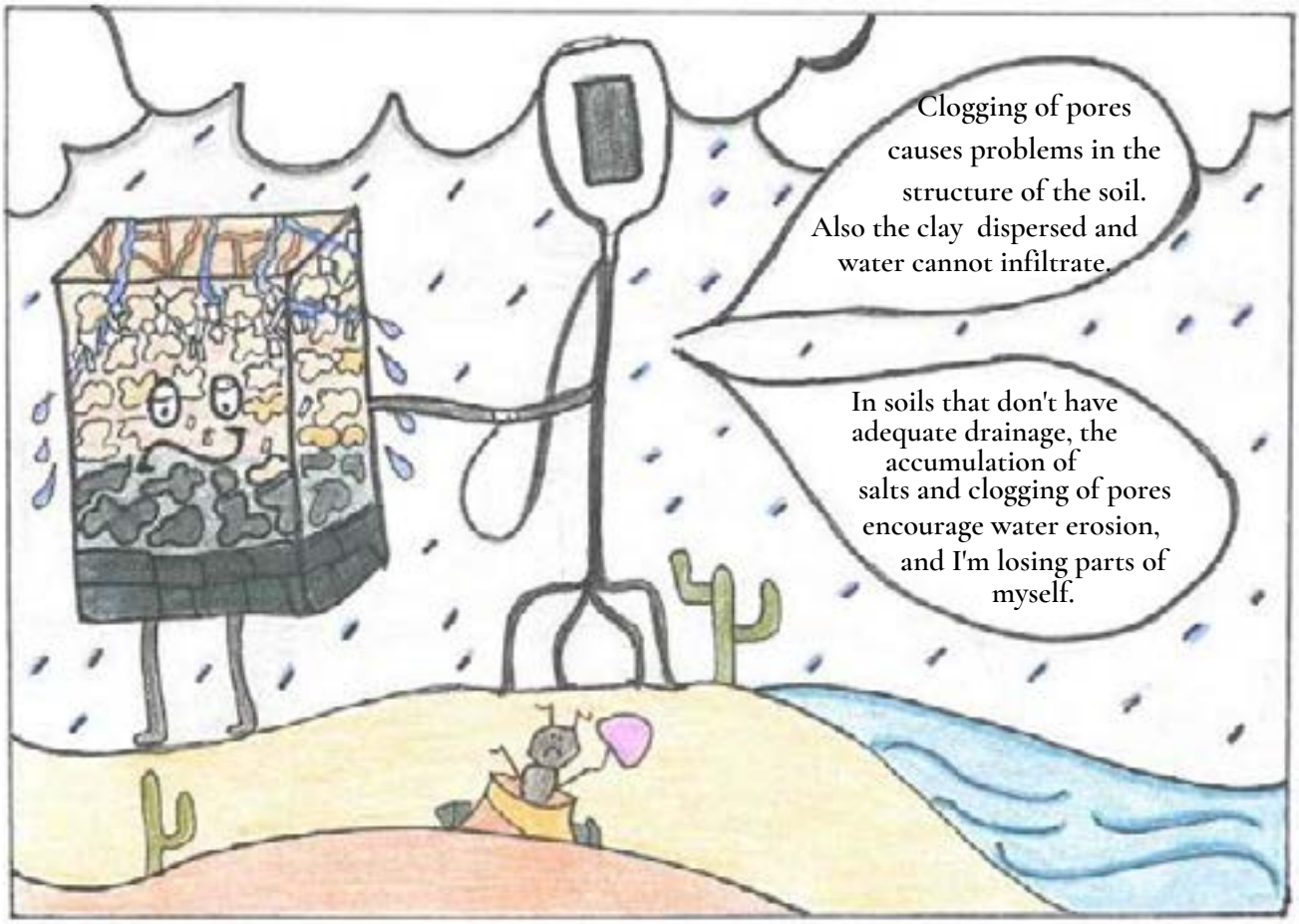


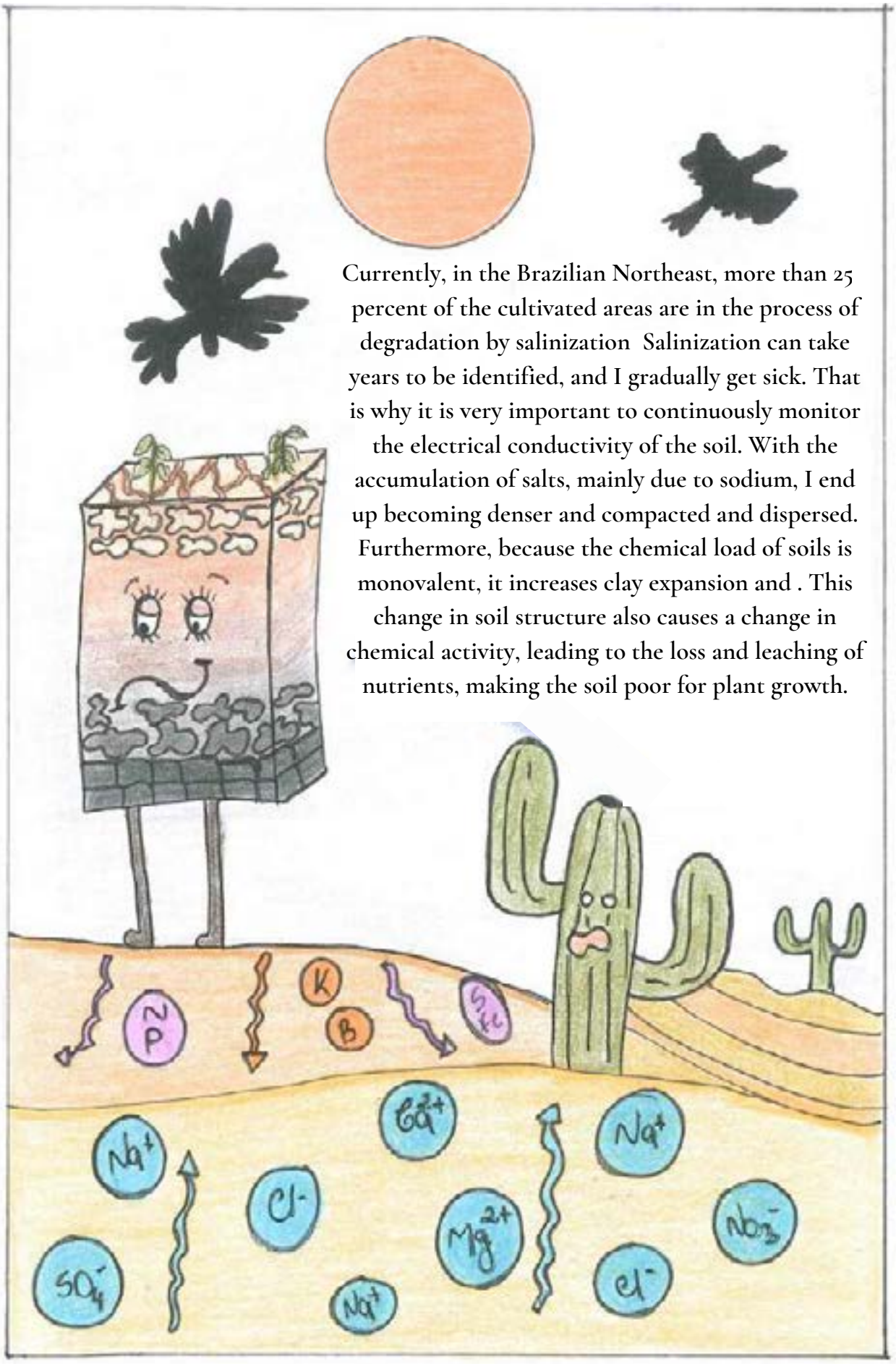
For me to be considered a soil with a good structure and not saline, there are some specific tests that the Dr. Soil Scientist performs, and they are: density and total porosity, electrical conductivity, chemical tests to determine the pH and sodium saturation and also the exchangeable amount of sodium.

The main indicator and also the fastest for Dr Scientist to do the analysis is the electrical conductivity of the soil, and he knows that everything is right when I have a low conductivity value. When I have high values for electrical conductivity, Dr Scientist knows something is wrong.

Where I live, the excessive heat with the scarcity of rain makes irrigation necessary to avoid a water deficit in plant growth. However, the water that is used most of the time is not of good quality and contains an excess of salts, which causes the accumulation of salts in the surface layer. Also, the high temperatures cause water to evaporate from the water table with the solution, the salts are carried away, these that accumulate on the surface and cause clogging of pores. The main salts that cause degradation by salinity are: sodium, magnesium and chlorine.

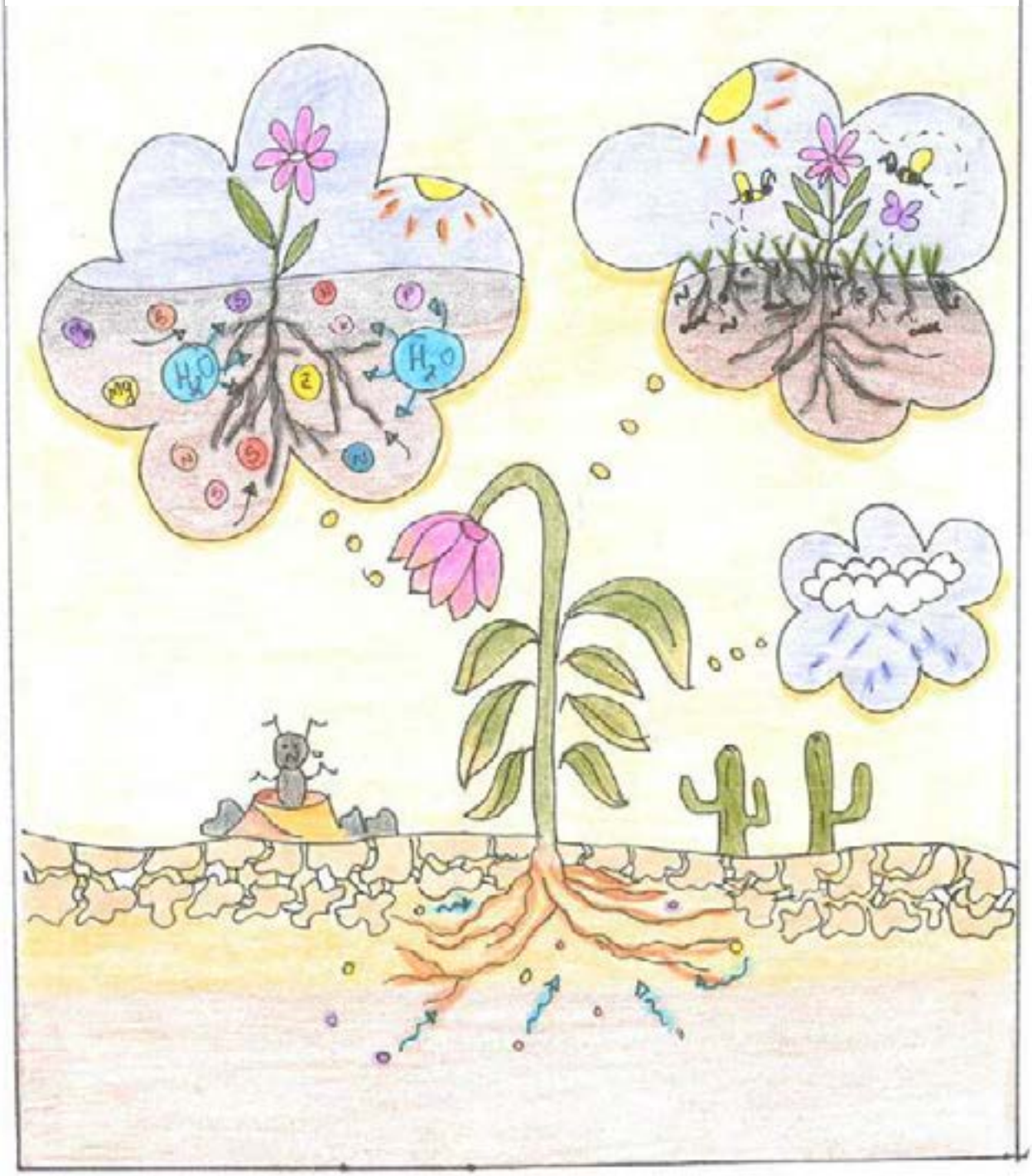




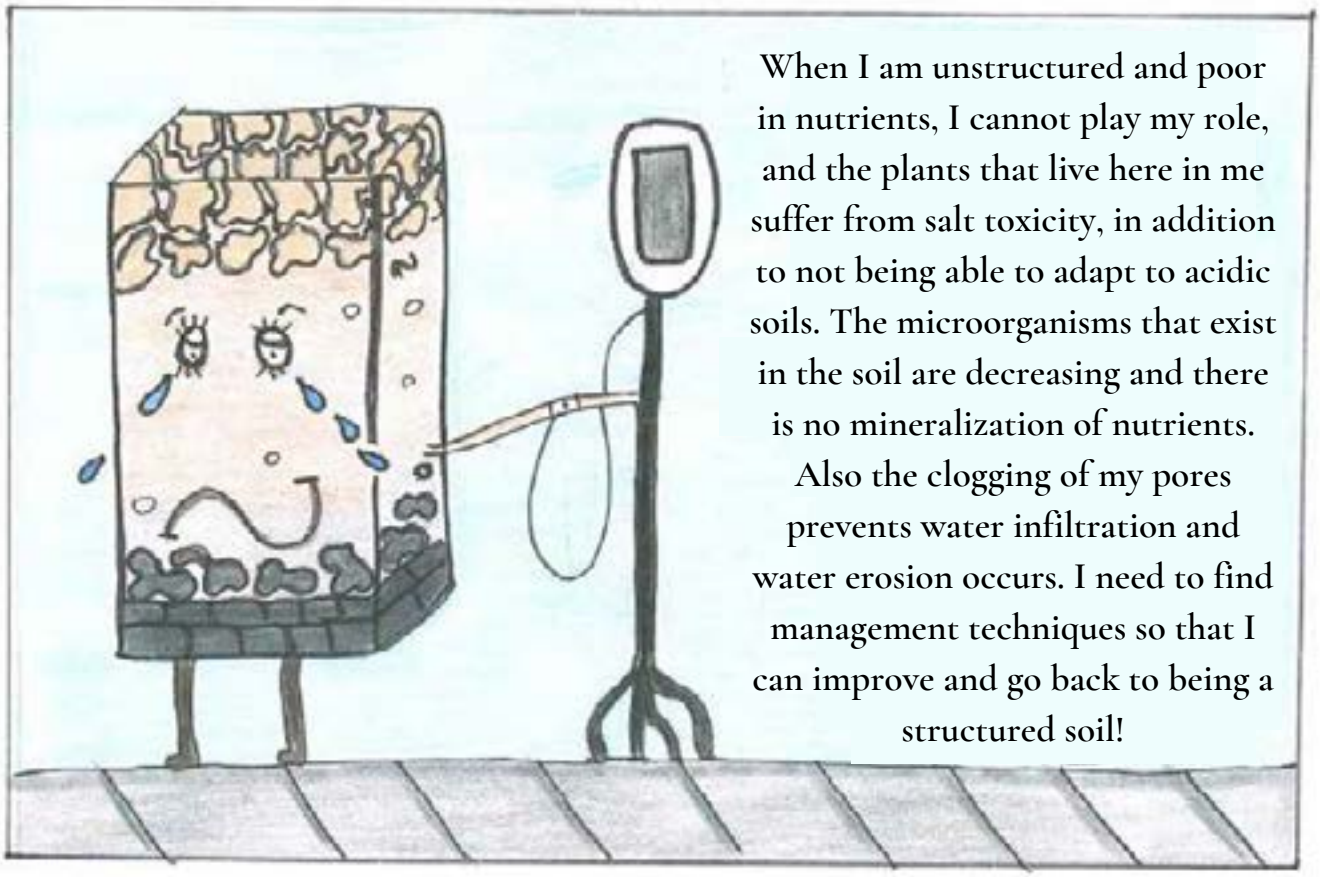


Currently, in the Brazilian Northeast, more than 25 percent of the cultivated areas are in the process of degradation by salinization Salinization can take years to be identified, and I gradually get sick. That is why it is very important to continuously monitor the electrical conductivity of the soil. With the accumulation of salts, mainly due to sodium, I end up becoming denser and compacted and dispersed. Furthermore, because the chemical load of soils is monovalent, it increases clay expansion and . This change in soil structure also causes a change in chemical activity, leading to the loss and leaching of nutrients, making the soil poor for plant growth.

When the salt contained in the soil is higher than the plant can tolerate, the plant also gets sick. Plant growth slows down as there is not enough water and nutrients in the soil. She could face a water deficit so big that she could die! The small amount of water that reaches the plant causes it to close its stomata, and thus, decreasing photosynthesis. All of this is caused because the salts in the soil alter all the osmotic potential of the soil and roots, making the plant very stressed!

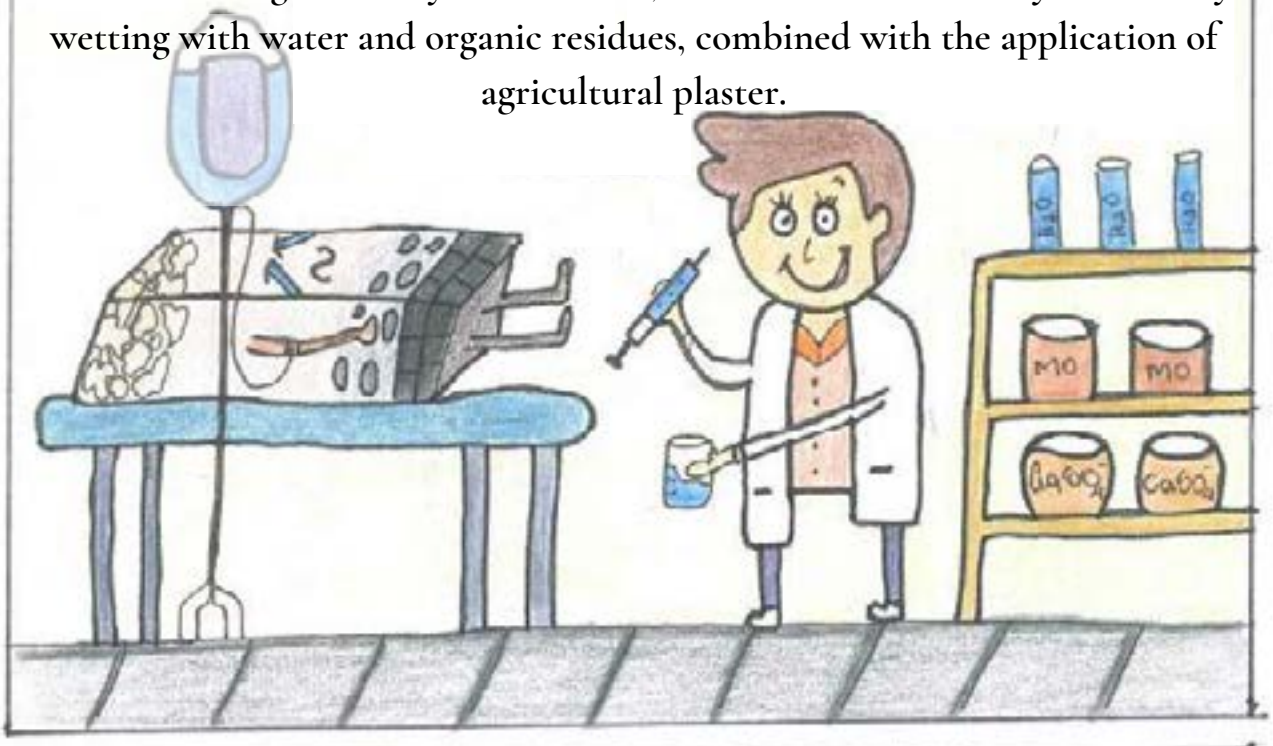


Dr Scientist can identify through laboratory analysis when I am in the salinization process. With the high electrical conductivity of the soil he can tell if there are too many salts in my pores. It can also identify which salts exist in the greatest number. Dr says when my pH is too low there are salts in the surface and sub-surface layers.

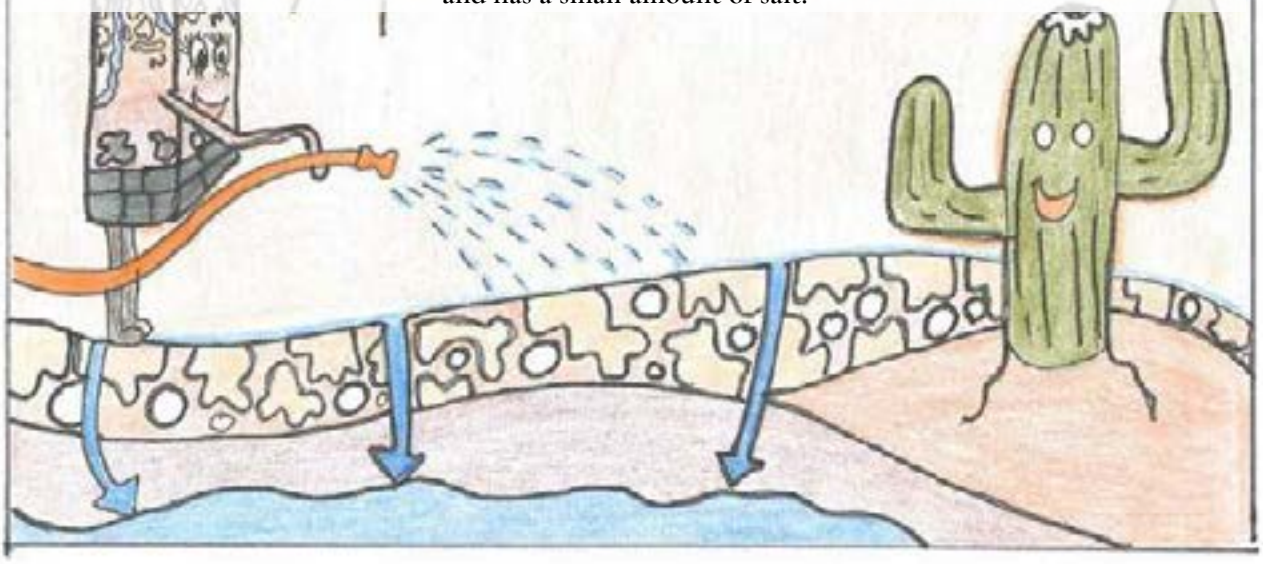


When I am unstructured and poor in nutrients, I cannot play my role, and the plants that live here in me suffer from salt toxicity, in addition to not being able to adapt to acidic soils. The microorganisms that exist in the soil are decreasing and there is no mineralization of nutrients. Also the clogging of my pores prevents water infiltration and water erosion occurs. I need to find management techniques so that I can improve and go back to being a structured soil!

When my exams are not right, Dr Scientist needs to study me and study what needs to be done to reduce salinity. It makes decisions based on the results obtained through its analyses. However, he said that the best way is to do my wetting with water and organic residues, combined with the application of agricultural plaster.

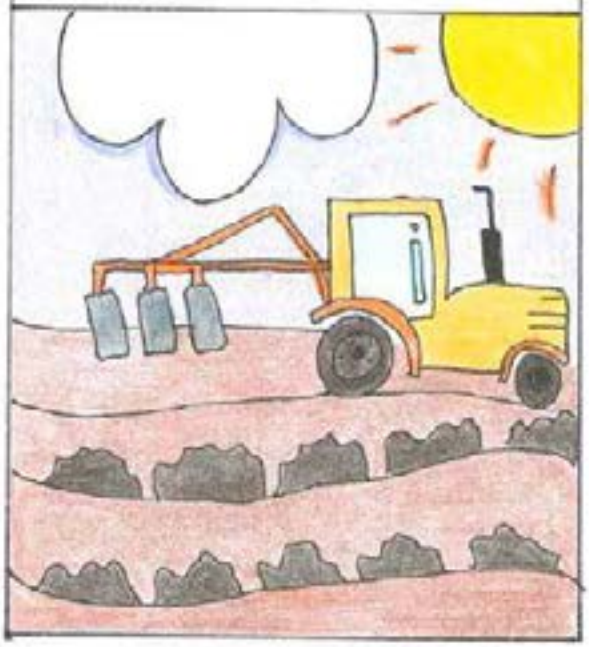


To control soil salinization it is necessary to use irrigation and drainage practices, as there is a need for water percolation in the soil profile, that is, the water needs to infiltrate me and travel through my pores. Along with the water that percolates in the soil, the salts also go down to the water table, unclogging the pores. The first step for pore cleaning to occur is leaching. It can be provided applying a water depth greater than the amount of water the plant needs. In this way the salts will be leached out. Leaching is the key to successful irrigation, in soils where salinity is excessive, it is also considered to be the only means by which soil salinity can be maintained at acceptable levels without risk to the crops. The water used for irrigation must be water that is considered to be of good quality and has a small amount of salt.



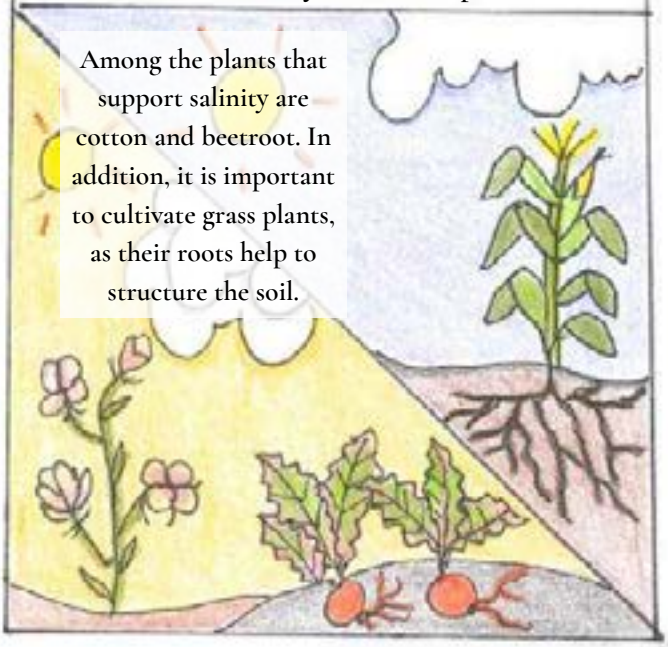
The application of agricultural gypsum is also important, that's why Dr Cientista do Solo performs all the exams to know the right amount to apply. He says that the calcium that is present in plaster, as it has a positive charge, takes the place of sodium in the connection with the negative charges. So sodium is easily carried along with water in the leach, and it no longer clogs my pores! That way I can move the water and air inside me!

The Dr Soil Scientist also recommended the increase of organic material along with soil disturbance, as organic matter contains ions that regulate chemical bonds, causing weak bonds such as sodium to break down and it leach out.



In growing areas here in the semiarid region, it is important to use plants tolerant to salinity, because even if there is adequate management, because of the material that gave rise to Luvisols like me, there will always be a small portion of salt.

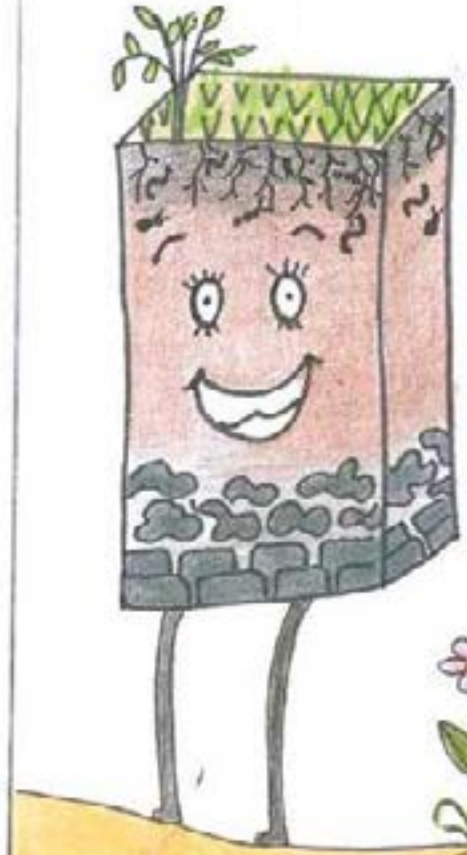
Among the plants that support salinity are cotton and beetroot. In addition, it is important to cultivate grass plants, as their roots help to structure the soil.

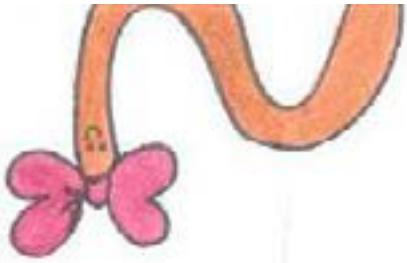


How good it is to be well and recovered!!!! With the use of proper management techniques I can keep the levels of salts in the soil within the tolerable range! Furthermore, there is no loss of soil and no degradation due to salinization. It is very important to be careful with me, I have the responsibility to support the productive cultures that will feed all the inhabitants of the planet.

Every decade there is an increase in population and with that it is necessary to increase food production, and for that I need to be performing all my functions. It is essential that human beings conserve me and maintain my biological functions.

And now friends, are we going to take care of our soils and keep this resource in perfect condition?





Let's put into practice what we've learned?

Soil salinity is:

a) Excess salts in the soil

b) Excess nutrients that the plant needs.

c) Few salts in the soil.

Why is excess salts in the soil bad?

a) because it gets salty

b) because the soil degrades and plants do not grow;

c) the salt in the soil is okay.

Which soil class does Ricky belong to:

a) Luvisols

b) Gleysols

c) Nitisols

Bye bye, thank you guys!!!

Reversing salinity, Preserving soil

Authors

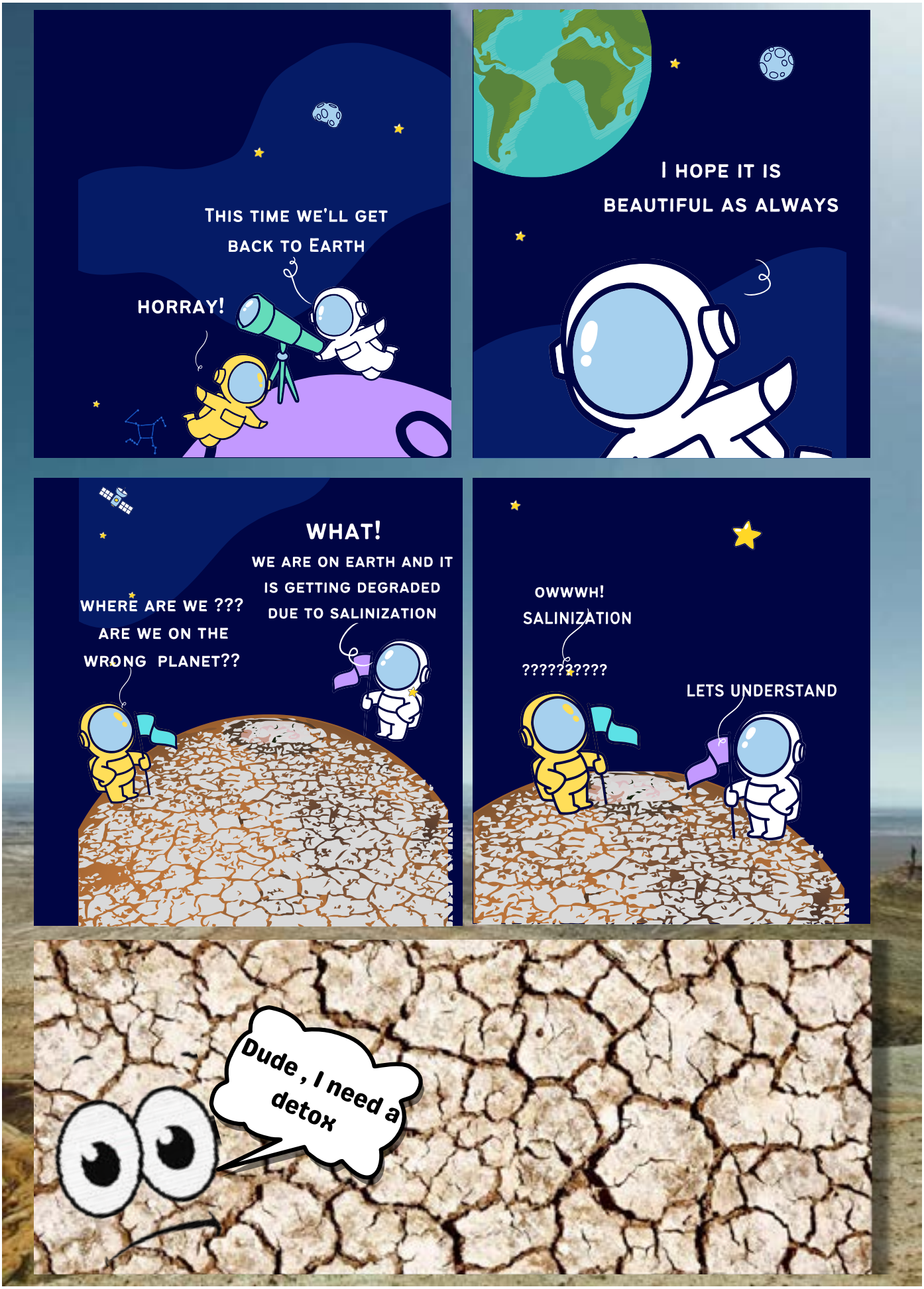
Tirunima Patle accomplished her degree programme B.Sc. (Ag) from the College of Agriculture, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, in 2015 and completed her M.Sc. (Ag) in Soil Science and Agricultural Chemistry from the College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalayain, Indore, also in 2015. She is currently pursuing a Doctorate of Philosophy in Soil Science at the College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, with ongoing research work.

Reversing Salinity, Preserving Soil

Halt soil Salinization,
boost Soil Poductivity

BY TIRUNIMA PATLE

CONTENT


THIS TIME WE'LL GET BACK TO EARTH
HORRAY!
I HOPE IT IS BEAUTIFUL AS ALWAYS
WHERE ARE WE ??? ARE WE ON THE WRONG PLANET??
WHAT!
WE ARE ON EARTH AND IT IS GETTING DEGRADED DUE TO SALINIZATION
OWWWH! SALINIZATION
??????????
LETS UNDERSTAND
Dude , I need a detox

SALT AFFECTED SOILS

SALINIZATION

- SALT AFFECTED SOILS CAN BE DEFINED AS SOILS WITH HIGH LEVELS OF DISSOLVED SALTS AND/OR HIGH CONCENTRATIONS OF ADSORBED SODIUM IONS IN SOIL MATRIX

- SALTS ARE ESSENTIAL COMPONENTS OF THE SOIL ECOSYSTEM, BUT DUE TO CERTAIN ENVIRONMENTAL CONDITIONS, EXCESS SALT ACCUMULATES IN THE SOIL HORIZONS, WHICH LATER DETERIORATES THE SOIL'S PHYSICOCHEMICAL AND BIOLOGICAL PROPERTIES.

- BASED ON A SYSTEM DEVELOPED BY THE US SALINITY LABORATORY, SALT-IMPACTED SOILS CAN BE BROADLY CLASSIFIED AS EITHER SALINE, SODIC OR SALINE-SODIC.

Soil Type	pH	EC (dSm^{-1})	ESP
Saline	< 8.5	> 4.0	<15
Sodic	> 8.5	< 4.0	> 15
Saline-sodic	> 8.5	> 4.0	> 15

EXTENT OF PROBLEM

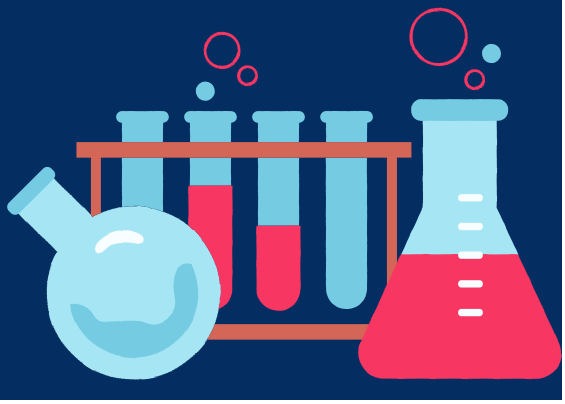
At the global level, 810 million ha are affected by sodicity (434 million ha) and salinity (376 million ha)

10 million ha of land are lost because of salinity caused by irrigation each year.

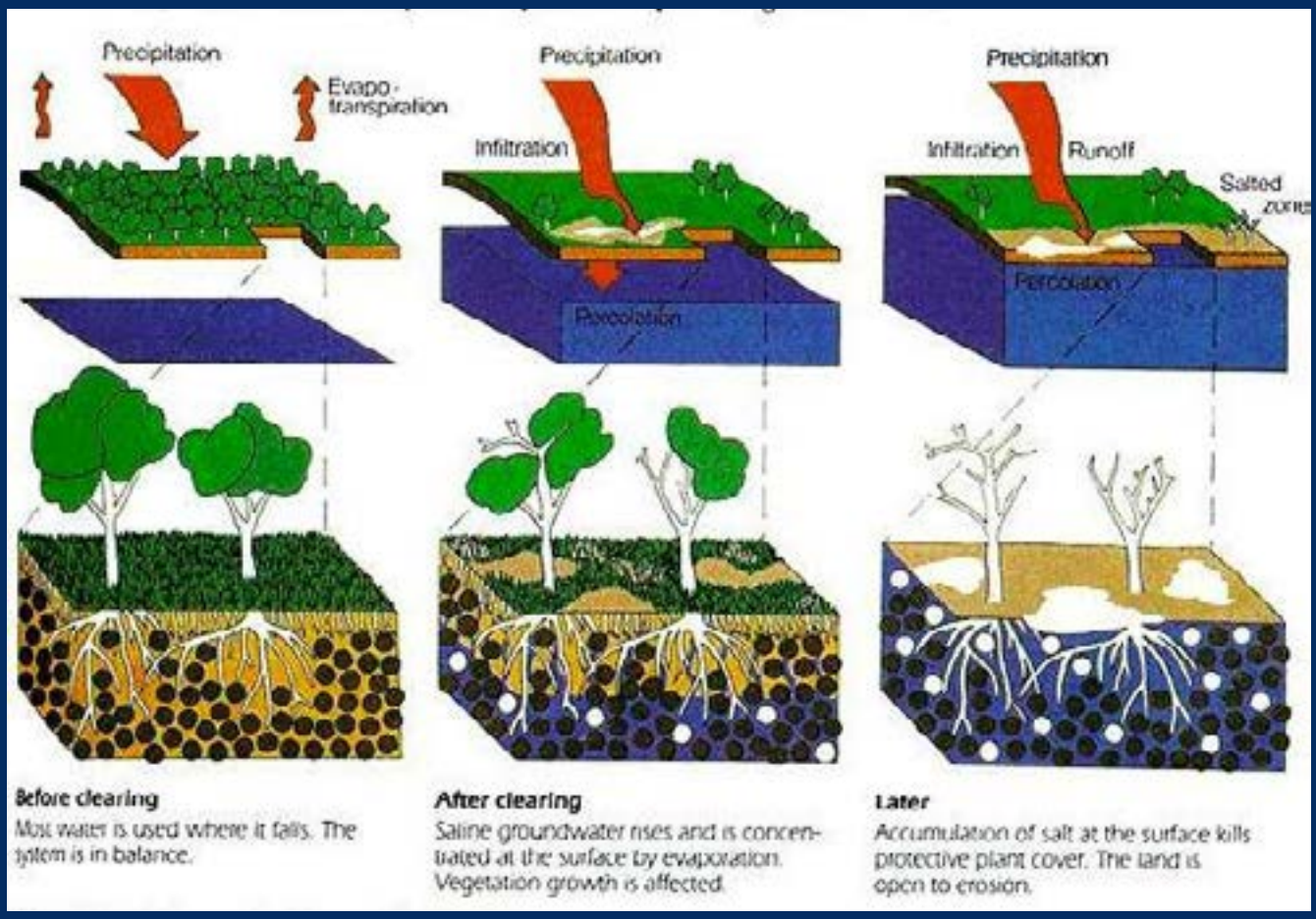
25 % of ground water used for irrigation is either saline or brackish

Characteristics of Salt Affected Soils (SASs)

Properties	Saline soil	Sodic Soil	Saline-Sodic Soil
pH	7.5-8.5	> 8.5	8.5-10.0
ESP	< 15	> 15	> 15
EC (dSm^{-1})	> 4	< 4	> 4
Salts	Chlorides and sulphates of Ca or Mg	Carbonates and bicarbonates of Na	Both
Total soluble salts	Less than 0.1 %	Less than 0.1 %	More than 0.1 %
Colour of soil	White	Black	-
Organic matter	Less	Very less	Variable
Physical condition	Flocculated , permeable to air and water	Deflocculated , very poor permeability	Depends on presence salts of Ca or Na
Other names	White alkali, Brown alkali, Solon chack	Black alkali , Typical usar, Sodic soil	Usar soil



PROCESS OF SALT ACCUMULATION ON SURFACE



What causes Salinity?

1. Primary source of salts in soil is from rock weathering

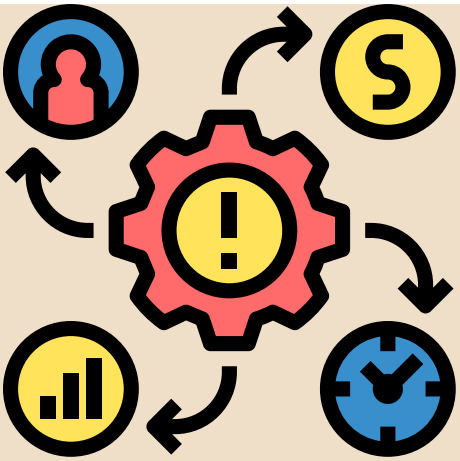
2. Fluctuating depth of ground water

3. In arid region less rainfall is available to leach the salt and high rates of evaporation cause concentration of salts in soil at various layers

4. Coastal Area: Due to inundation of sea water

5. Irrigation water containing high concentration of soluble salts

Diverse effect of Salinization

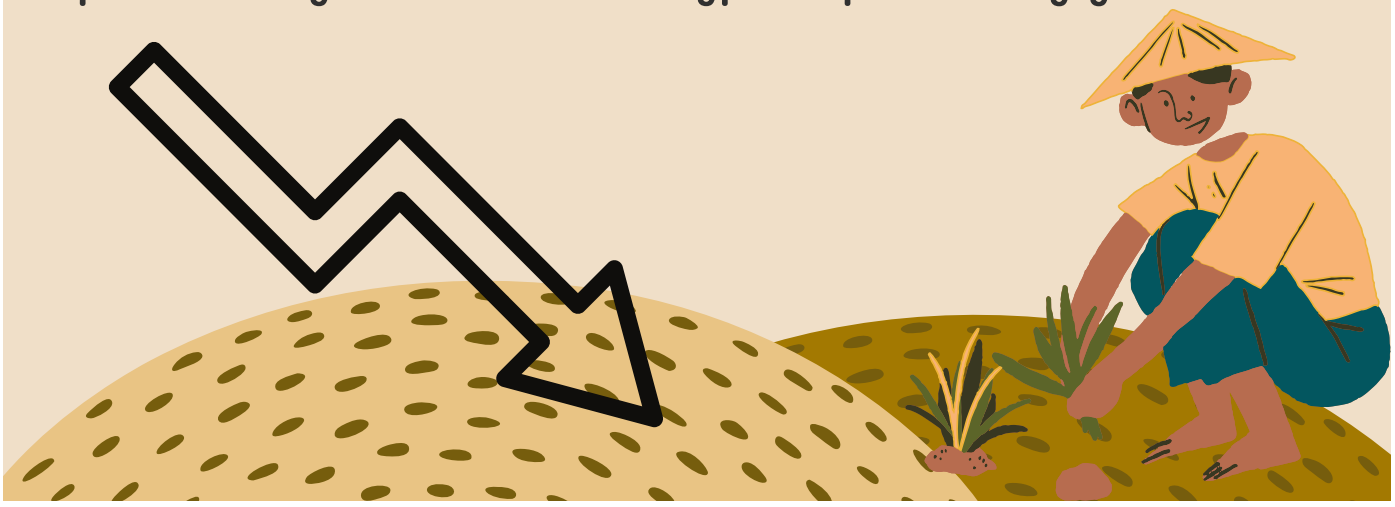


The presence of salinity in soil and water can affect plant growth in three ways:

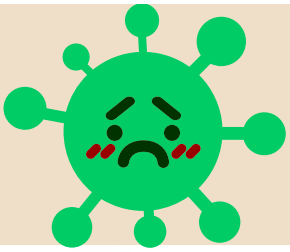
(1) it can increase the osmotic potential and hence decrease water availability;

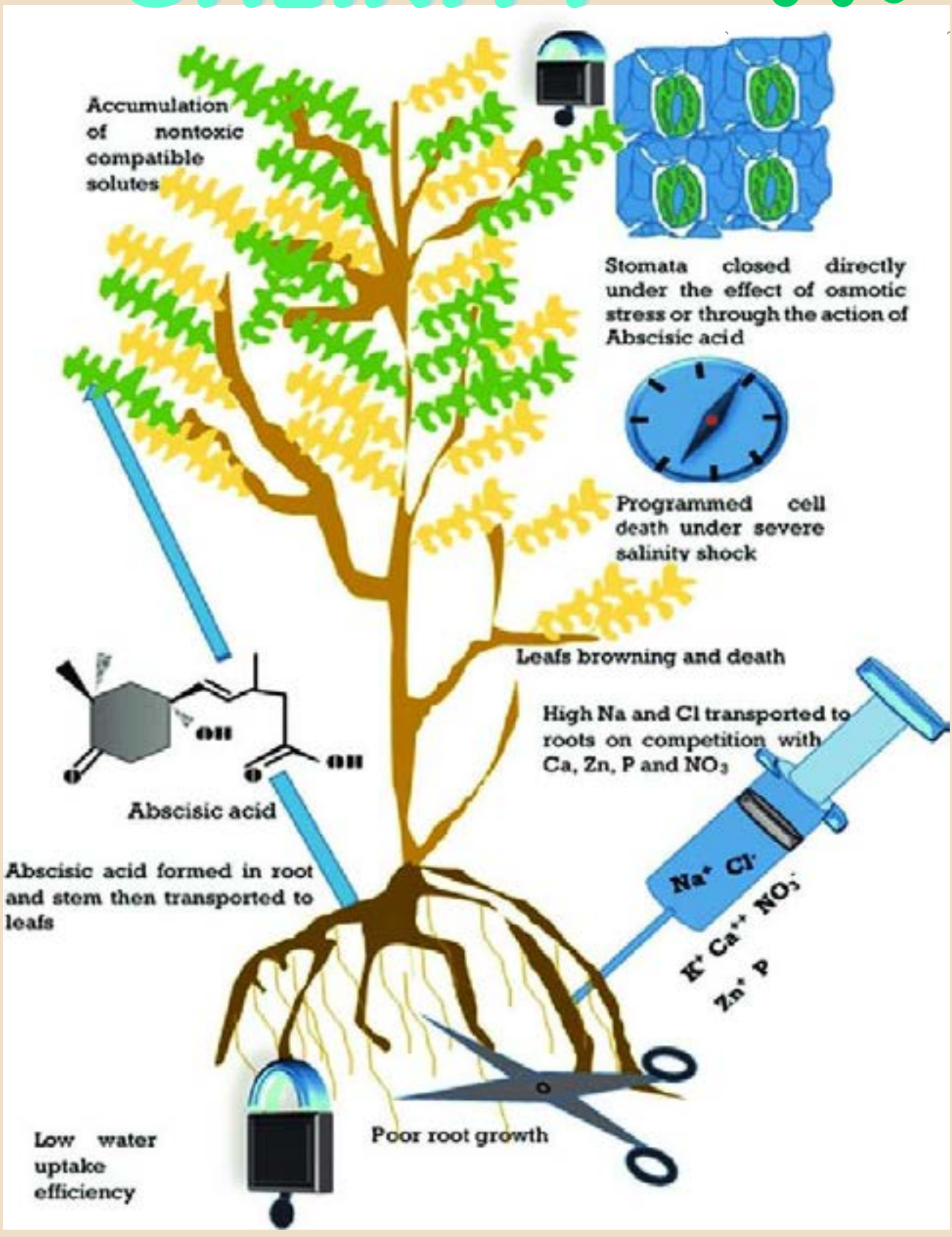
(2) it can induce specific-ion effects by increasing the concentration of ions with an inhibitory effect on biological metabolism;

(3) it can diminish soil-water permeability and soil aeration by adversely affecting soil structure. The adverse effects of soil salinity on plant growth and productivity varies with the type of plant being grown

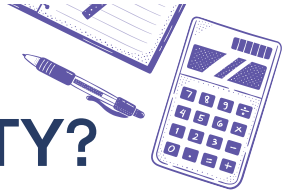


IMPACT OF SALINITY

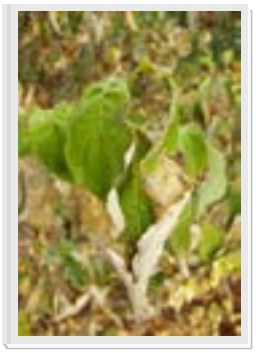




HOW DO YOU DIAGNOSE SALINITY?



diagnosing high Ph , Salinity , Sodicity problems

Problems	Potential problems
 1.Sodic Soil	**POINT 1** poor drainage , black podery residue on soil surface
2.Saline irrigation Problem	**POINT 2** Leaf burn , poor growth, moisture stress 
3.Saline Soil and Saline Sodic Soil 	**POINT 3** White crust on soil surface , water stressed plants , leaf burn
4.High pH problems	 **POINT 4** Nutrient deficit yellow and dark green to purple leaf

HOW TO REVERSE SOIL SALINITY?

THERE ARE SEVERAL TECHNIQUES TO TACKLE SALINIZATION AND IMPROVE AGRICULTURAL PRODUCTIVITY:

INCREASE DRAINAGE FOR BETTER FLUSHING (TO REMOVE SALTS FROM THE GROUND SURFACE).

PLANT SALT-TOLERANT CROPS TO MANAGE ECONOMIC RISKS AND TO ENSURE LAND COVER.

REMOVE SALT CRYSTALS FROM THE SURFACE MECHANICALLY.

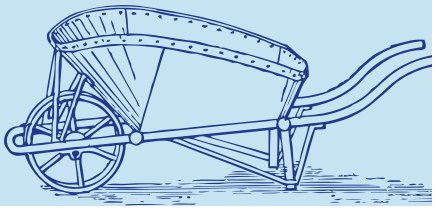
RESTORE THE BALANCE VIA CHEMICAL AMENDMENTS (E.G., GYPSUM OR SULFURIC ACID).

PRE-TREAT SEEDS WITH NACL TO PROMOTE SEED GERMINATION.

REDUCE EVAPORATION WITH MULCH OR CROP RESIDUE.

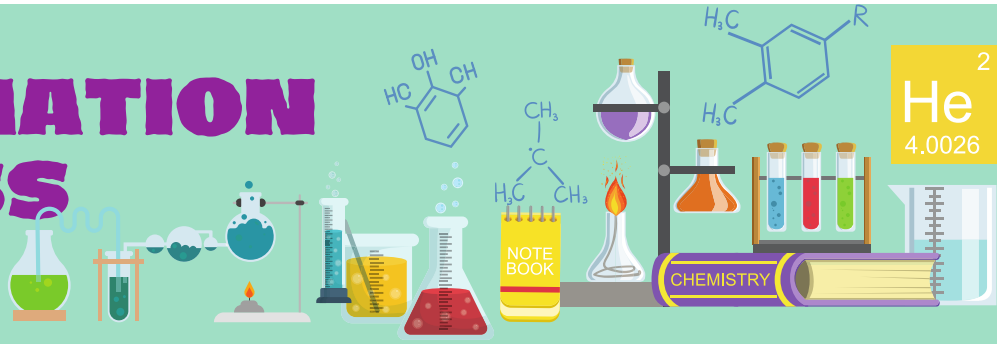
GROW CROPS THAT CAN ABSORB MOISTURE PROPERLY TO AVOID PROLONGED WETNESS OF LANDS.

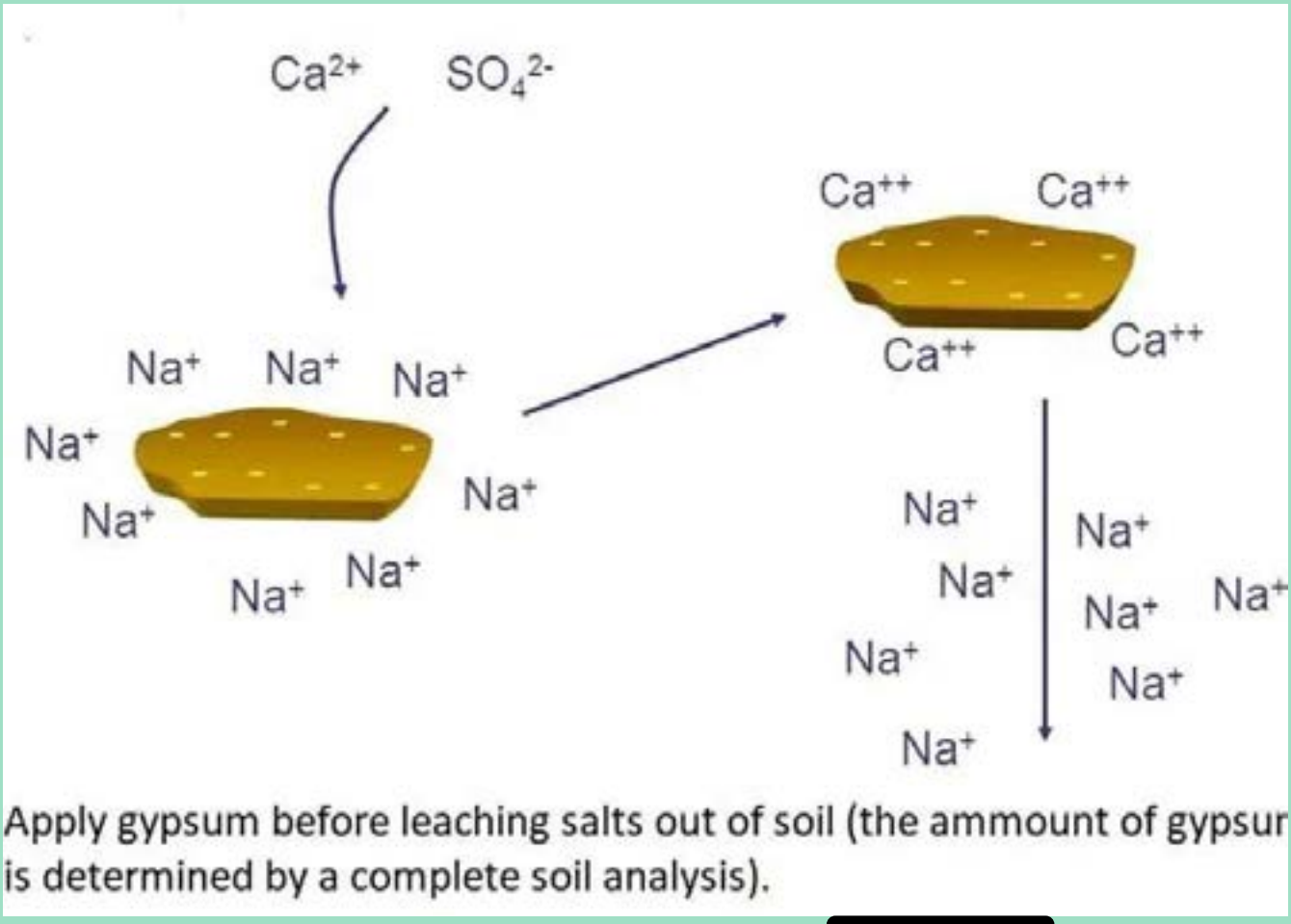
APPLY FERTILIZERS RATIONALLY, AS AN OVERUSE OF CERTAIN CHEMICALS PROMOTE SALINIZATION.



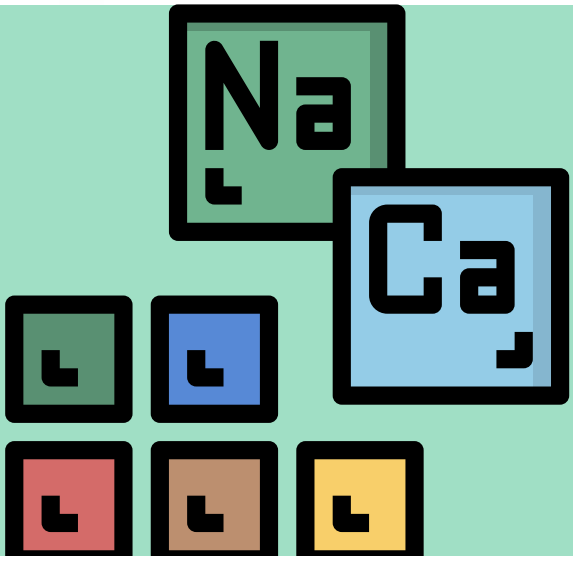

SALT AFFECTED SOILS RECLAMATION
HYDRAULIC METHOD
Flushing
Leaching
Efficient Drainage
CHEMICAL METHOD
Amendments
Mineral Fertilizer
Soil Conditioning
BIOLOGICAL METHOD
Bio Saline Agriculture
Mulching
Blue Grean Algae
Green Manuring
ORGANIC MATTER
PHYSICAL METHOD
Planting Techniques
SUB SOILING
Scraping
Land Leveling

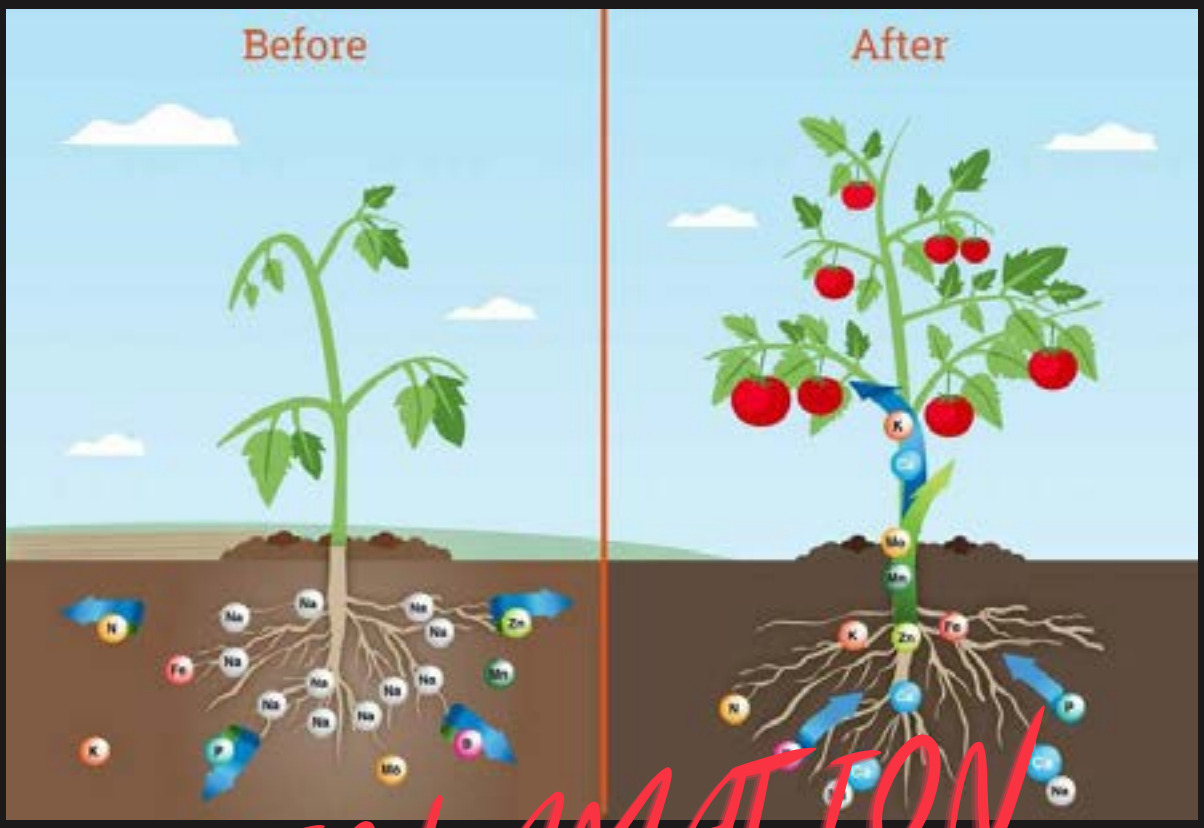
RECLAMATION PROCESS



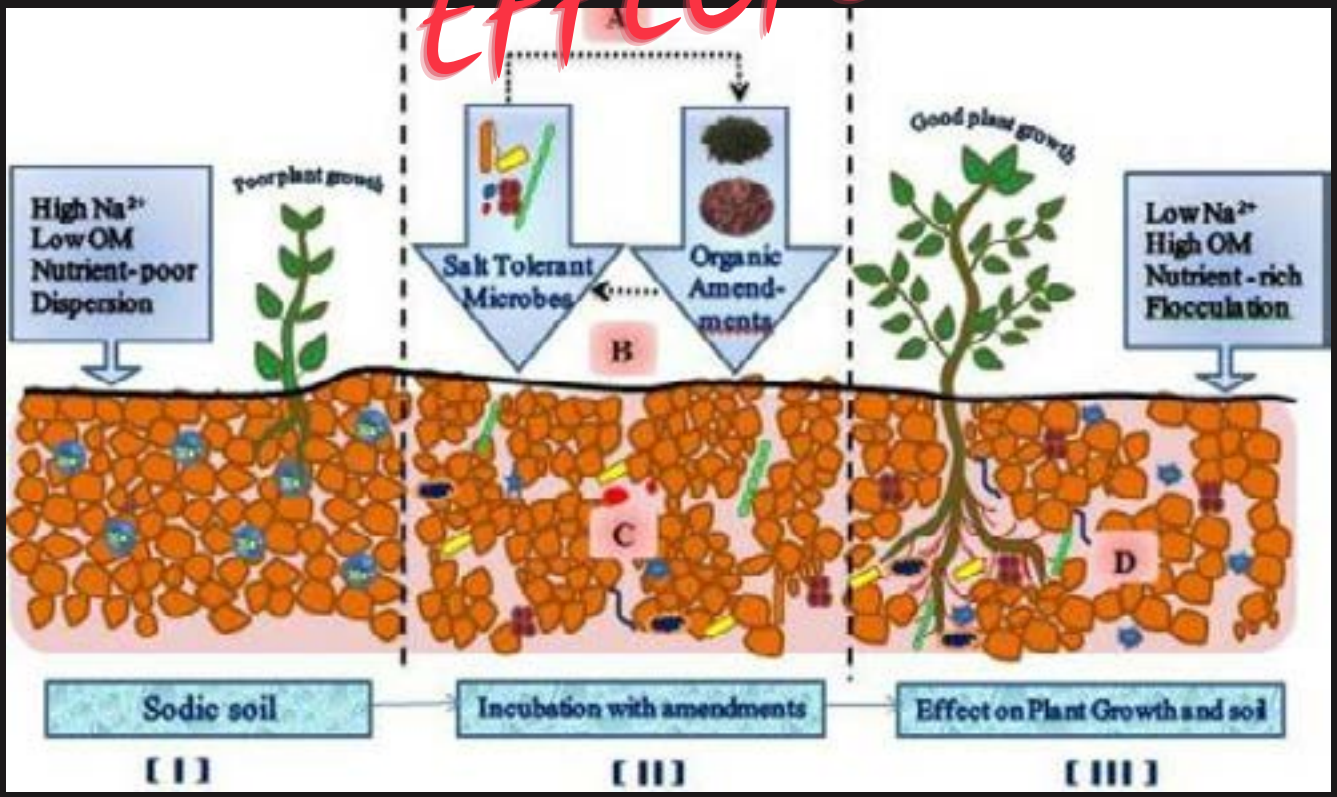


Apply gypsum before leaching salts out of soil (the ammount of gypsur is determined by a complete soil analysis).





RECLAMATION EFFECTS



Soil: Reading Comprehension

Salinization of soil is becoming a major agricultural problem worldwide, mainly in arid and semi-arid regions. The higher salinity level poses adverse effects on soil properties and plant physiology. There are two main factors of soil salinization, i.e., primary salinization by natural causes and secondary salinization by anthropogenic actions. According to the projections, it is assumed that the world population will cross 9 billion marks by 2050, which would require an increase of 57% in food production. Soil salinity is a major factor that decreases agricultural productivity and poses a challenge to the agricultural capacity to sustain an increasingly growing population. Nevertheless, elevated concentrations of salts in the soil are harmful to the soil ecosystem, which adversely affects plant physiology, microflora, and soil-dwelling organisms.

Salts are essential components of the soil ecosystem, but due to certain environmental conditions, excess salt accumulates in the soil horizons, which later deteriorates the soil's physicochemical and biological properties.

Over the years, soil salinization was not given much attention, but the reduced availability of arable landmasses and the drastic changes in the land-use paradigm has intensified the problem. The problems like food security, land degradation, desertification, unavailability of arable lands, etc. have emerged issues related to social conflict for natural resources. New Journal Pre-proof Journal Pre-proof requirements are emerging out due to burgeoning population demands, that every patch of land must be used according to the best-suited purpose and with best transformations dealing with adaptive, feasible and sustainable techniques. Numerous research shows the deleterious effects of salinity on soil properties, microflora, seed germination, plant growth, and soildwelling organisms. In the presence of these deleterious effects, it has been a challenge for the agricultural system to meet the current and future global food demands and ensure food security. Many soil salinity alleviation techniques are traditional and have gained popularity, but they are not perfect for solving overall problems induced by salinity to the agricultural sector. Considering contemporary issues, modern techniques are coming up with new advancements to ensure efficient, feasible, and sustainable saline soil management approaches. Out of the available management techniques, some focus on enhancing plant properties (seed priming, afforestation, crop selection, genetic improvements, agroforestry), some are well focused on enhancing soil properties (chemical amendments, biochar, earthworms, and their vermicompost, compost, microbial inoculants, electro remediation), and some techniques enhance both soils as well as plant properties in a synergic manner. Despite emerging modern techniques, there is a need for more in-depth researches which are synergic, integrated, and more sustainable to cope with the salinity issue. These emerging strategies will help in attaining some of the major goals of the UN-SDGs like goal 2 (zero hunger), goal 8 (recent work and economic growth), goal 12 (responsible consumption and production), goal 13 (climate action), and goal 15 (Life on land). In conclusion, the integrated approaches may result in better agricultural output and economic profit.

Soil Salinity: Reading Comprehension

Using sentences, answer the following questions based on the information given.

1. What are the two main factors of soil salinization

- _____
- _____
- _____

2. Importance of Salts

_____

_____

_____

_____

3. Explain Salinization

_____

_____

_____

4. What are the types of Soil Salinization

_____

_____

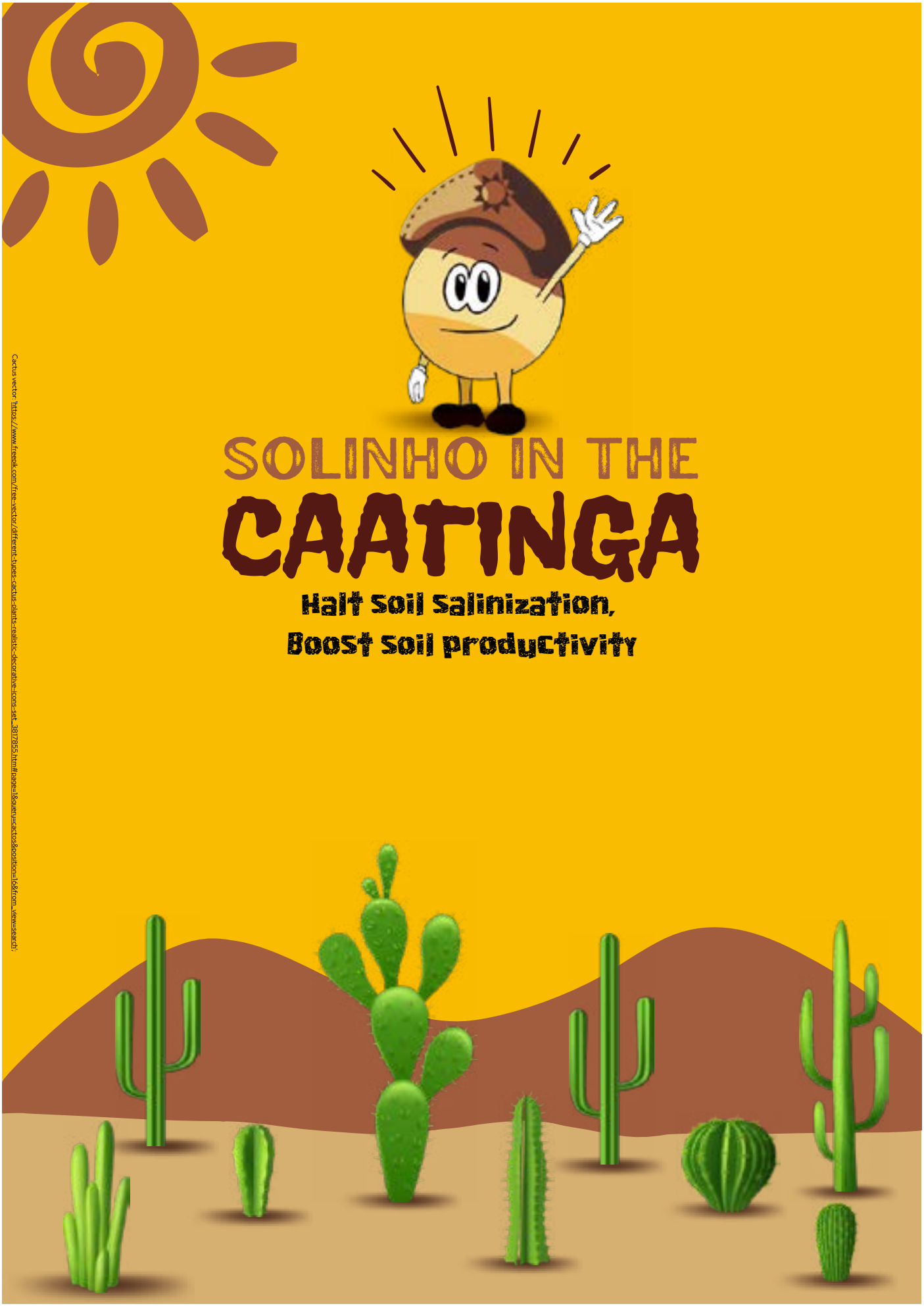
5. what are the strategies for attaining major goals of the UN-SDGs

_____

Solinho in the Caatinga

Authors

The authors of "Solinho in the Caatinga: Halt soil salinization, Boost soil productivity" are members of Programa Ponte Solo na Escola (PPSNE). Despite the PPSNE being hosted into the University of São Paulo, Brazil, authors were from different nations: **Bruna Arruda** (Colombia); **Marcia Vidal Candido Frozza** (Brazil); **Nayana Alves Pereira** (Brazil); **Clécia Cristina Barbosa Guimarães** (Brazil); **Aldeir Ronaldo Silva** (Brazil); **Antonio Carlos de Azevedo** (Brazil) made the research about soil salinization and converted it into the history involving the mascots and characters of PPSNE. **Tiago Ramos de Azevedo** (Brazil); **Josiane Millani Lopes Mazzetto** (New Zeland) and **Wilfrand Ferney Bejarano Herrera** (Colombia) designed the characters; **Beatriz Rosa Chiodeli** (Brazil) made the book design and **Cyan Turner** (United Kingdom of Great Britain and Northern Ireland) revised the English grammar.



Cactus vector: https://www.freepik.com/free-vector/different-types-cactus-plants-realistic-decorative-icons-set_3817855.htm#page=1&query=cactos&position=16&from_view=search;

Introduction

This booklet tells the story of the Brazilian Caatinga, the only biome exclusive to this country, which means that most of the natural habitats and history cannot be found anywhere else on the planet.

Most of the Caatinga is found in the Northeast region of Brazil,and has a wide variety of organisms living there due to the characteristically dry climate. However, a dry climate can also cause salt to build up in the soil in some places, in a process called salinization, which can affect how the organisms in these environments live.

Salinization can worsen by human actions, and so people need to come together to stop the problem, since it takes a long time for these areas to recover once the salt builds up, and often costs more money than people want to spend.

Thus, with a little poetic license, we are bringing together stories and science to explore solutions that, although not always possible in the real world, are being studied to solve the problem of salinization.

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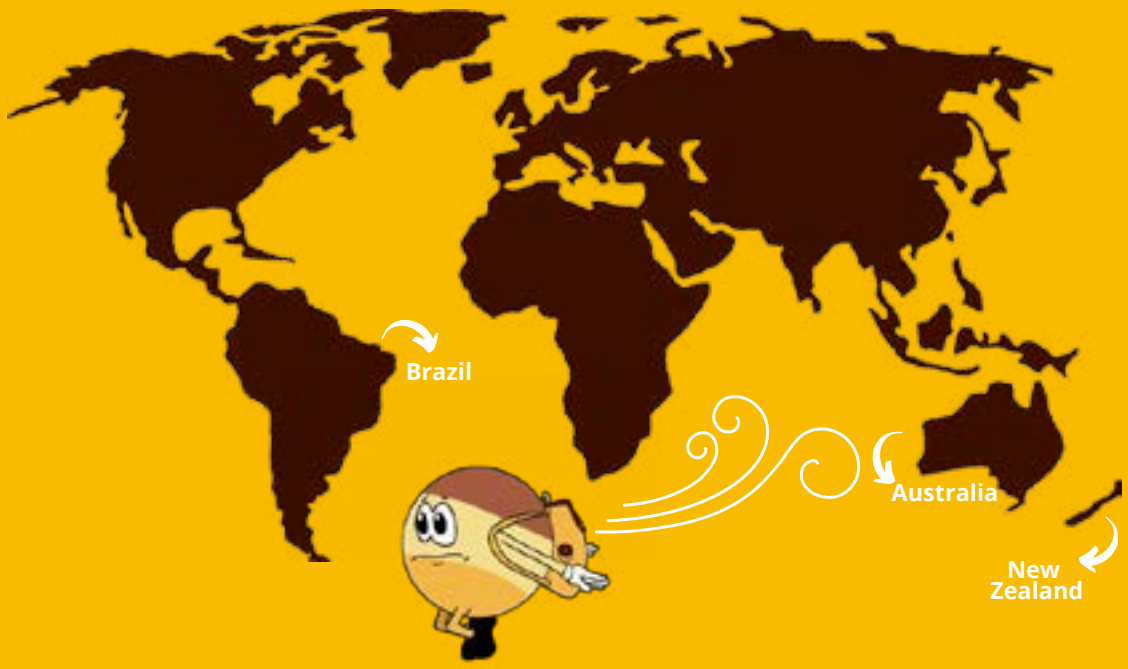
Solinho, after his adventure in the Amazon, was called to a place in New Zealand that needed his help. Only a few organisms were left and most of them were dehydrated, the animals thirsty and the plants wilting in the soil. Soon after arriving, Solinho got another report that an area in Australia had a similar problem.

As the two problems were very similar, the communities worked together and swapped ideas and information in search of a solution. It took much work, but eventually the soils and organisms in those places began to recover. Solinho's mission was complete! His friends would continue to work, restoring the soil, but they were now on the right track. However, before Solinho could even say goodbye, he received a new call for help, this time from Brazil.

He immediately hitched a ride with the Wind Current towards Brazil.



Solinho arrived to where the call had come from and he saw a lush green landscape and an imposing dam. However, just by the side of this was a large desert-like area that caught his attention. The place looked bleak and desolate.

There was only a solitary ant waiting for Solinho, visibly relieved to see him.

The Ant continued, "However, for some time now life has been difficult, even with all of this water."

Although the area was mostly deserted, the irrigation system had continued to be maintained in an attempt to bring back life to the arid soil.

Solinho already had an idea of what the problem might be. To confirm his suspicions, he pulled out a conductivity meter from his ever-present backpack and analysed the water coming out of the pipes. Now he knew for sure.

An irrigation system is a technique that has been used since the Persian Empire. It works by channelling water to make it available to the soil in a controlled way, and it is often used in agriculture.

Note:

A conductivity meter measures the amount of salt in a water sample by measuring how quickly electricity passes through it. The more salt there is, the higher the electrical current!

"Dear Ant, I know what the problem is," Solinho said. "I have just come from places that had a similar problem and, after a lot of work, they were able to start making the soil better again."

Solinho pulled out his notebook, as well as other things he needed for a demonstration.

Salinization is a worldwide problem that has been occurring in different regions all over the planet. It has many different causes, which means that each region has to be investigated by researchers to help understand the process.

You can also do experiments to find out what happens when there is too much salt in the soil, as the University staff explains on the next page!

To understand what is happening, Solinho and Ant set up an experiment using table salt (Sodium chloride, NaCl)

$Na^+ + Cl^- \longleftrightarrow NaCl$

Na^+ = sodium (ion)

Cl^- = chlorine (ion)

NaCl = Sodium chloride (salt)

What you need

- 2 containers
- soil
- marker (pen)
- labels
- seeds (your choice)
- water
- table salt

Example:

What to do

- Fill 2/3 of the two containers with soil;
- With the marker/labels, label the containers with "salt" and "no salt";
- Put the same amount of seeds in each container (for beans, three are enough, for smaller seeds, it can be more)
- Cover the seeds with soil;
- In the container labelled as "no salt", add tap water (without drowning the soil);
- Make a saline solution by adding two pinches of salt to a cup of water and mix well. Add this to the container labelled as "salt" (without drowning the soil);
- Place the two containers in a sunny spot;
- Observe the experiment for a week. If the soil dries out during the week, water it again with tap water for "no salt" and the saline solution for "salt".

What happened?

1.Carefully remove the seeds/seedlings from the containers, being careful to keep them separate.

2.Describe how the seeds/ seedlings are:
No salt: _____
Salt: _____

3.Was there germination?
No salt: yes ( ) no ( )
Salt: yes ( ) no ( )

Note:

Germination is the first stage of a plant growing. The seed splits open and small shoots and roots start to come out. Can you see this happening with your seeds?

In the table to the side, you can find some examples of plant responses to lots of salt in the soil.
Some can grow when the Exchangeable Sodium Percentage (ESP) is above 40, so they are more tolerant and thrive in a saline soil.
Others cannot tolerate this and are therefore considered sensitive to excess salt.

Table 1. Relative tolerance of cultures* to exchangeable sodium (Ayers; Westcot, 1999)

Sensitive (ESP<15)	Semi-tolerantes (ESP de 15 a 40)	Tolerantes (ESP>40)
Cowpea	Wheat	Rhodes Grass
Chickpea	Tomato	Angola Grass
Peanut	Spinach	Cotton
Lentil	Sorghum	Bermuda Grass
Tangerine	Rye	Sugar Beet
Peach	Rice	Beetroot
Orange	Radish	Barley
Grapefruit	Onion	Alfalfa
Pea	Oat	
Corn	Mustard	
Cotton (germination)	Clover	
	Sugar cane	
Bean	Millet	
Nut	Lettuce	
Deciduous fruits	Fetusca	
Avocado	Carrot	

* Listed in ascending order of tolerance

Adaptaded from: Ayers & Westcot (1999 apud DIAS et al. 2016, p. 156; available on: https://www.ars.usda.gov/arsuserfiles/20361500/pdf_pubs/P2542.pdf)

SALINIZATION

Natural causes

Global factors can cause the accumulation of salts in the soil:

- Transport of salt particles by the winds that blow from the sea to the continents;
- Transport of salts by wind in areas next to mineral exploration zones, such as mines.

Local factors can also cause salinization:

- Types of rocks in the local area which give rise to different soil types;
- Seasons of prolonged droughts;
- Fluctuation of the water table.

Human action

Some human practices can accelerate the salinization process or make it worse. One example is the use of saline water in irrigation systems.

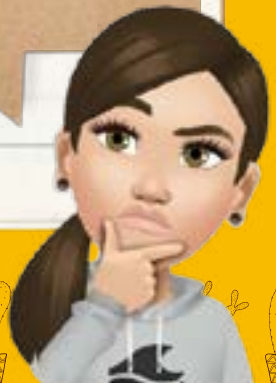
Salinization in Brazil

Although salinization can be seen in different areas all over Brazil, it is more common in the Northeast, due to the natural conditions of this region.

Water can turn into a gas easily, in a process called evaporation, but the salt in that water does not. This means the salt from evaporated water is left behind in the soil, causing salinization. When there is not much rain, there is no water to "wash" the concentrated salt out of the soil.

Some areas in the Northeast have high average temperatures, which leads to high levels of evaporation. This combined with little rain to replace this water means the areas are highly salinized.

The soil in the Northeast region of Brazil is formed through the dry climate and flat landscape. The combination of these factors leads to a soil more susceptible to salinization.



Consequences of Salinization

- Loss of soil porosity due to the physical effect of salts;
- ·Loss of flora and fauna, as many organisms cannot tolerate lots of salt in the soil.

What happens to plants when they are planted in soil with an excess of salt?

When seeds are placed in soils with accumulated salt, where the elemental concentration is higher in the soil than in the seed, the water in the seed will leave to go into the soil to balance the salt concentration. The loss of water can cause the seed to wither and die.

With salt

What happens to plants when they are planted in soil without excess of salt?

In soils without excess salt, the seeds can absorb water from the soil because they have a higher concentration of elements in the seed than in the soil. This water makes them germinate and develop.

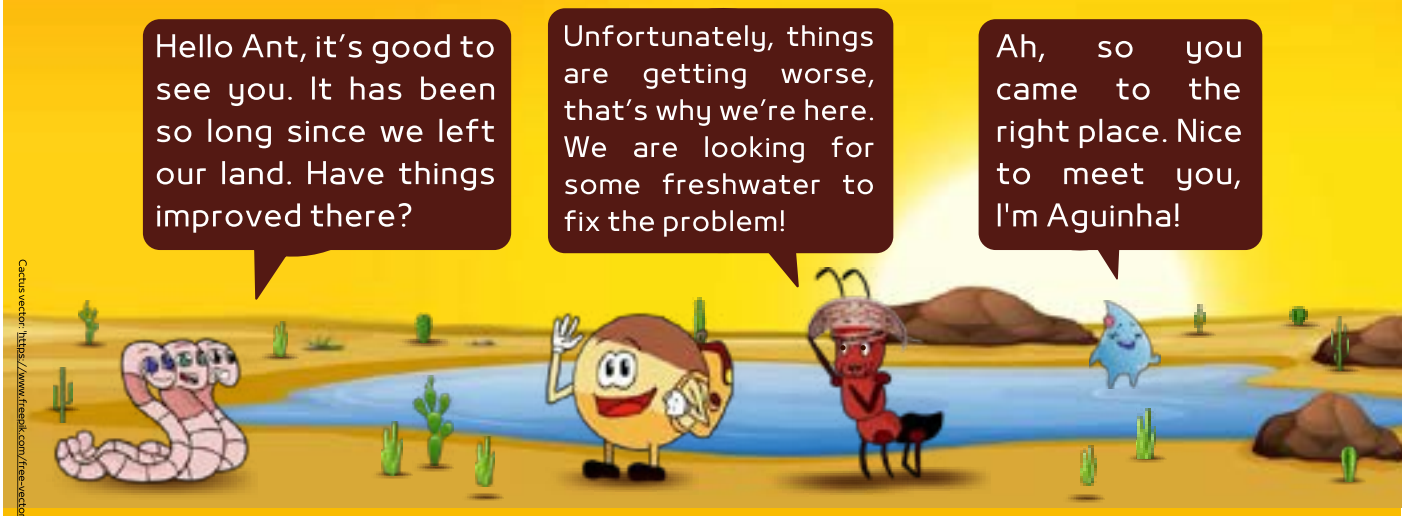
Without salt

Osmosis is the movement of water from a less concentrated solution to a more concentrated one through a **semipermeable membrane**, one that lets gases and liquids pass through, until the concentration is equal on each side.

Bean Cycle: https://br.freepik.com/vetores-gratis/ciclo-de-vida-do-feijao-verde_1470971.htm#page=1&query=feij%C3%A3o&position=38&from_view=search;

After Solinho studied the site's conditions, he talked to Ant. They would need lots of unsalted water. He warned her the process would be long and hard.

Thus they went on a long and exhausting journey in search of water. When they got there, Ant was pleasantly surprised to find her earthworm friends, who were soil engineers.



Cactus vector: https://www.freepik.com/free-vector/different-types-cactus-plants-realistic-decorative-icons-set_3817855.htm#page=1&query=cactos&position=16&from_view=search;

Feeling encouraged by Aguinha's confirmation, Solinho and Ant explained their idea. The Earthworms were excited at the idea of finally going home and volunteered to help.

Soon, several organisms started to help transport fresh water to the area with too much salt in the soil. They were hoping to create and maintain a layer of water that would withstand evapotranspiration.

Evapotranspiration is the loss of water to the atmosphere through evaporation from the soil and movement through plants, which is called transpiration.

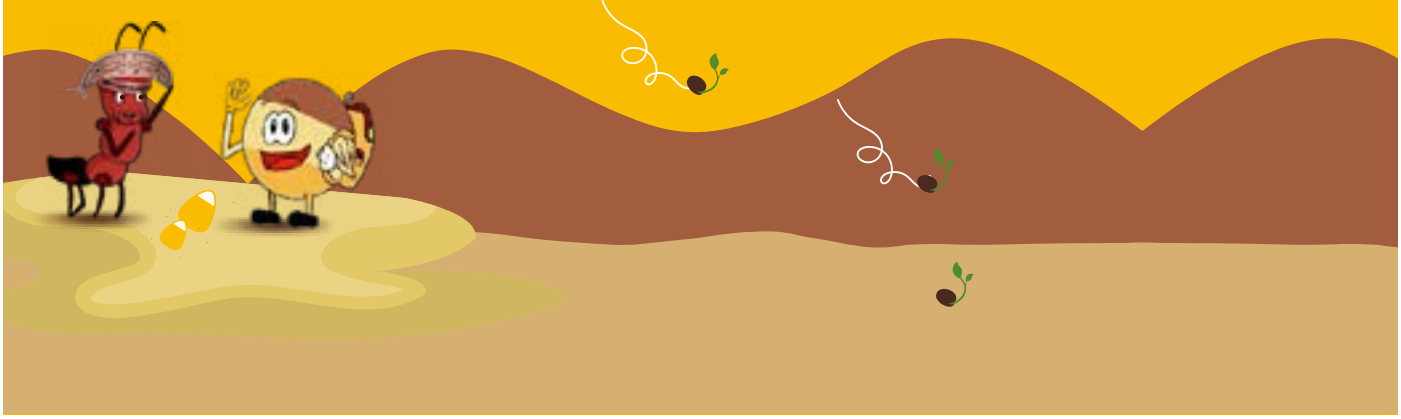
Before removing the salt from the soil, Aguinha said that washing the soil would not be enough, as the process would generate a lot brackish water that would need to be disposed of properly.

Solinho was a little discouraged, but Aguinha knew what to do, because she had already done some research.

After a lot of work, and washing the soil made brackish water, Aguinha decided it was time to put the second part of her plan into action. She asked the wind to bring her *Atriplex nummularia* seeds and spread them all over the affected region.

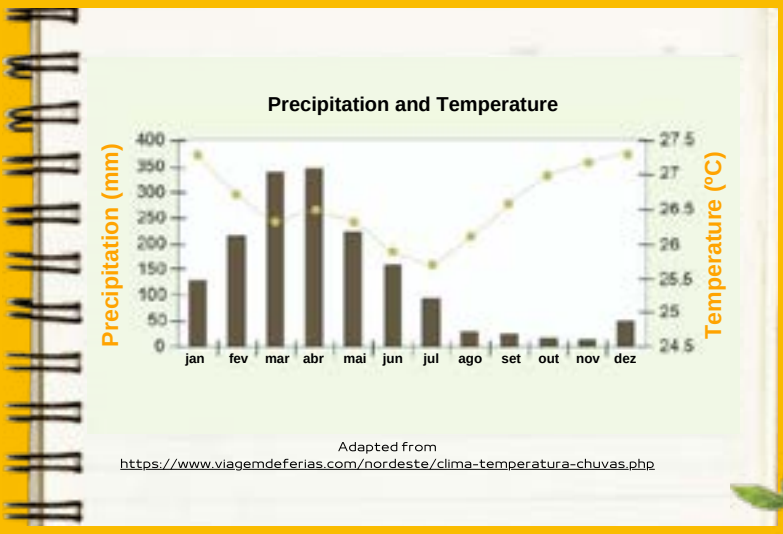
Atriplex nummularia (from the Chenopodiacea family), is a halophyte plant (a saline tolerant plant) used in the Northeast region of Brazil since the 1930s by its ability to accumulate significant amounts of salts in its leaves.

While they waited for soil to recover, Ant showed Solinho a collection of seeds that she had kept, hoping that one day she would be able to plant them and grow corn again.



As Solinho had warned, it was neither quick nor easy, but, finally, Aguinha and the halophyte plants managed to reduce the excess salt accumulated in the soil and other plants began to grow.

Finally, a very special day arrived, one that Ant had long awaited.



Adapted from
https://www.viagemdeferias.com/nordeste/clima-temperatura-chuvas.php

In the graph to the side, the grey bars show the amount of rain in a month and the orange points show the temperature for a part of the Northeast region of Brazil.
The first months of the year are rainier; therefore, it is the best time to sow seeds.

Carefully, Ant and Solinho planted the corn seeds in the soil. Aguinha helped by watering the soil, and everyone eagerly awaited for them to germinate.

Cactus vector: https://www.freepik.com/free-vector/different-types-cactus-plants-realistic-decorative-icons-set_3817855.htm#page=1&query=cactos&position=16&from_view=search;

In time, the roots of many plants began to grow and to spread the good news by reaching out to the organisms that lived in unaffected regions.

Click here to learn more about plant communication.

Cactus vector: https://www.freepik.com/free-vector/different-types-cactus-plants-realistic-decorative-icons-set_3817855.htm#page=1&query=cactos&position=16&from_view=search;

When they received the message, Ant's friends began to return to their homeland.

With everyone back and the corn growing beautifully, everyone was just waiting for the most important time of all: the corn harvest in June and the São João festival.

The São João festival in Brazil is celebrated in June. In the Northeast region, it is combined with the corn harvest, which gives rise to many delicious recipes.

Note:

Initially, leather hats were mainly used to protect the cowboy's head from the thorny weeds of the Caatinga, as well as from the sun and rain. But later it became a tradition due to Luiz Gonzaga, a singer-songwriter, who used several models of leather hat in his performances in the Southeast, to represent his northeastern origin.

Click here to listen to traditional music from Brazilian Northeast, written and performed by Luis Gonzaga.

When the festival was over, Solinho knew his mission was complete and that his friends would continue to look after the soil when he was gone.

The soil boosters against salinization

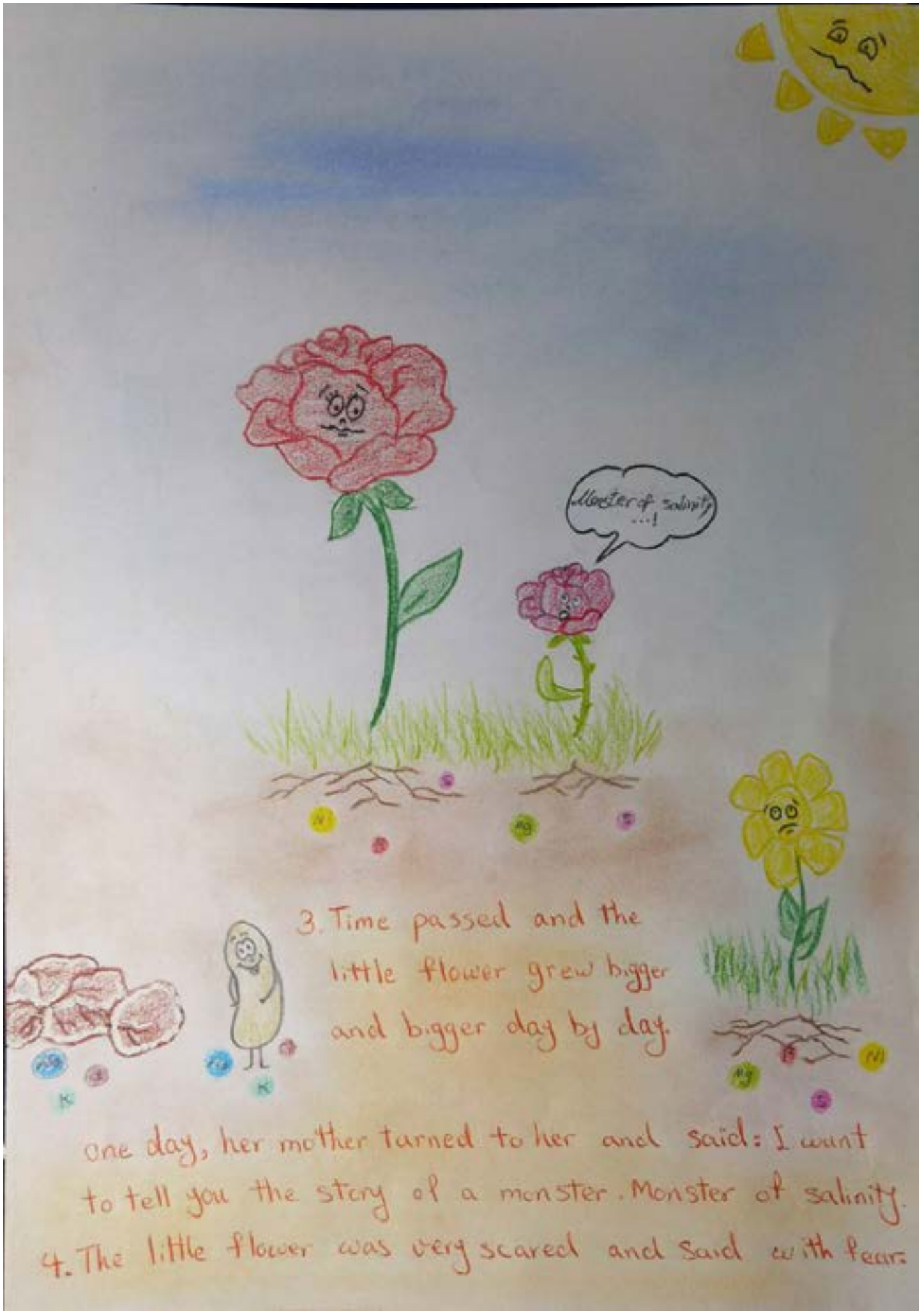
Author

Mehrnoush Eskandari Torbaghan was born in the Islamic Republic of Iran in 1981. She received a B.S. (2004), M.S. (2006), and PhD (2017) degrees in soil science from the Ferdowsi University of Mashhad. Currently, she is a researcher in soil science and has authored/co-authored more than 158 scientific papers in national and international journals. She is also the translator and author of seven books so far, conducted 25 research projects and currently has eight projects underway. Her current research interests are in the areas of soil biology, microbiology, extremophile bacteria, plant nutrition and abiotic stress reduction in plants. Her cousin, Ms **Elham Ghalasi** was a collaborator in making the booklet, helping with the drawing of the figures.


Food and Agriculture Organization
of the United Nations
The Soil boosters against Salinization

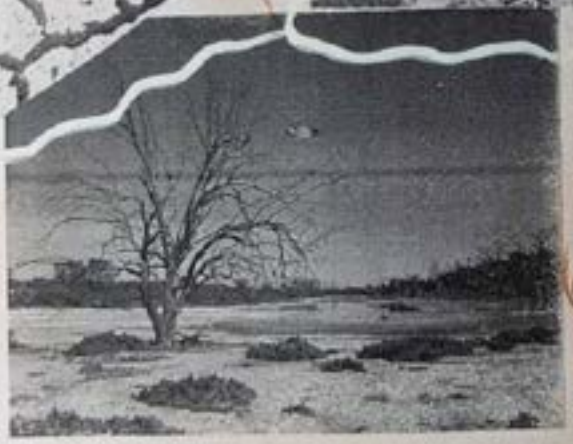

1. Once upon a time, it was plain where many flowers
and trees lived well and happity together for many years.

2. Somewhere in this plain, the little flower of story had just been born next to her mother and was getting to know the word around her.


Monster of salinity ...!
3. Time passed and the little flower grew bigger and bigger day by day.
one day, her mother turned to her and said: I want to tell you the story of a monster. Monster of salinity.
4. The little flower was very scared and said with fear:

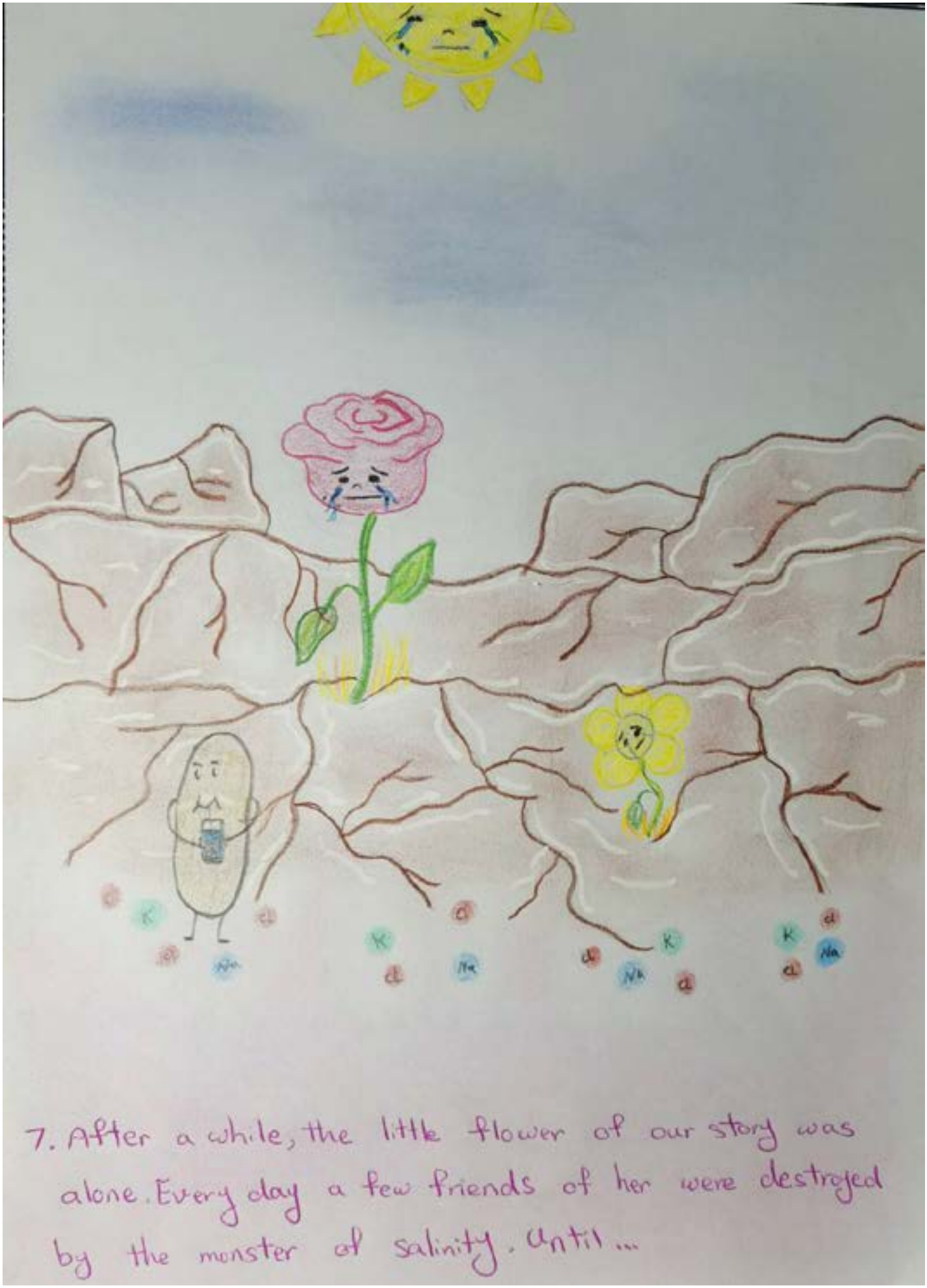
Monster!

Monster of salinity?!



5. Her mother said: Yes. The salinity monster is slowly coming and will dry us and our friends. It has no mercy on any of us.

6. The little flower thought to herself a littles and the she said You mean we will die too? Her mother said: Unfortunately, yes. Of course, I spent my life, but I am worried about you and your friends, as well as this plain, what will happen next.

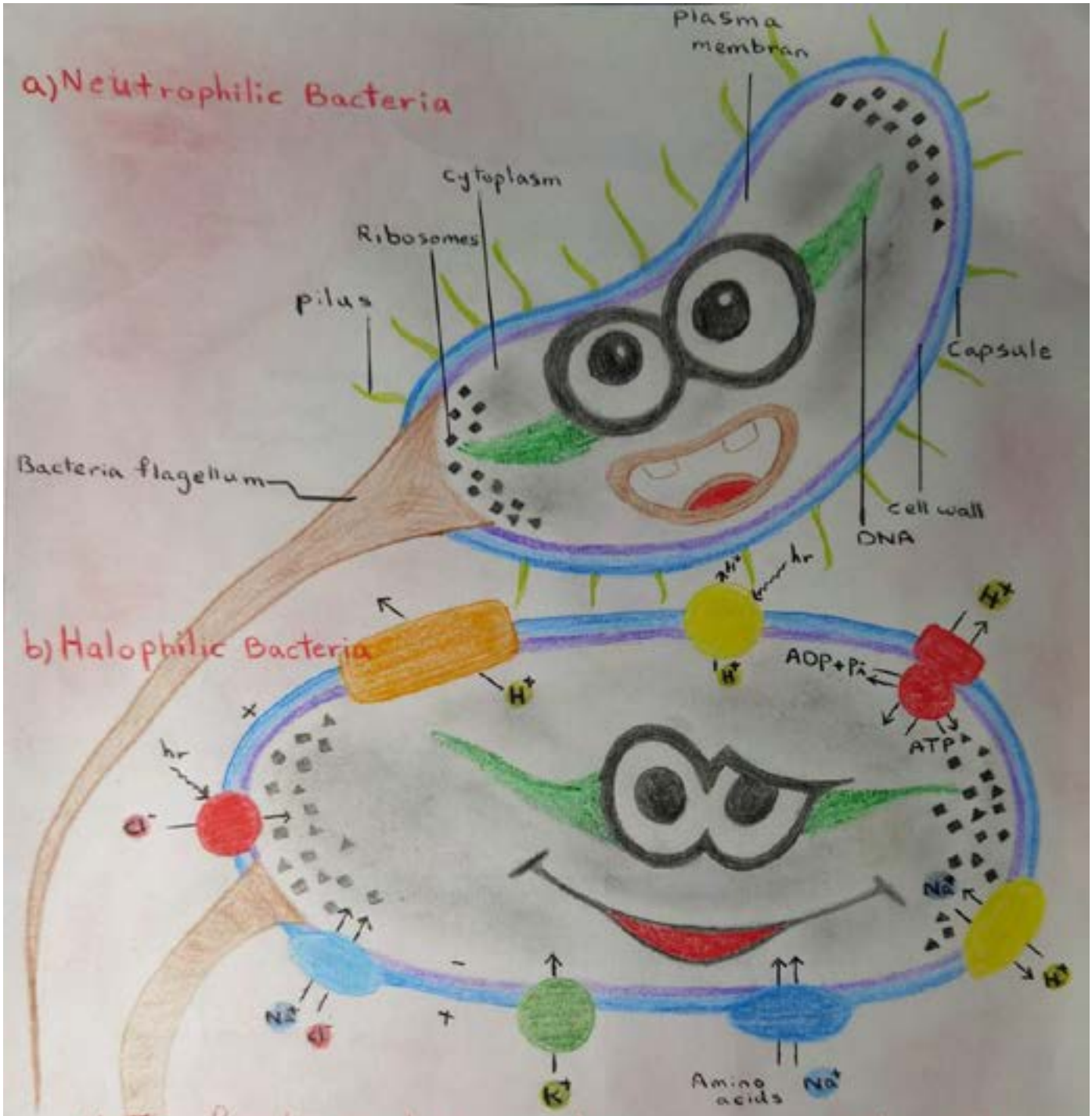


7. After a while, the little flower of our story was alone. Every day a few friends of her were destroyed by the monster of salinity. Until ...

8. one day she unconsciously heard a sound from the ground. The voice was the sound of celebration, joy, and dancing. It became a little more accurate. She heard two creatures talking to each other.

9. The first said to the second: You mean the salinity monster will not kill you? The second said with a laugh No! why shoud it kill? We are resistant to salinity monster and some of us love salinity.

10. The little flower looked at them in surprise and while they were talking warmly, She asked: what are your names, please?



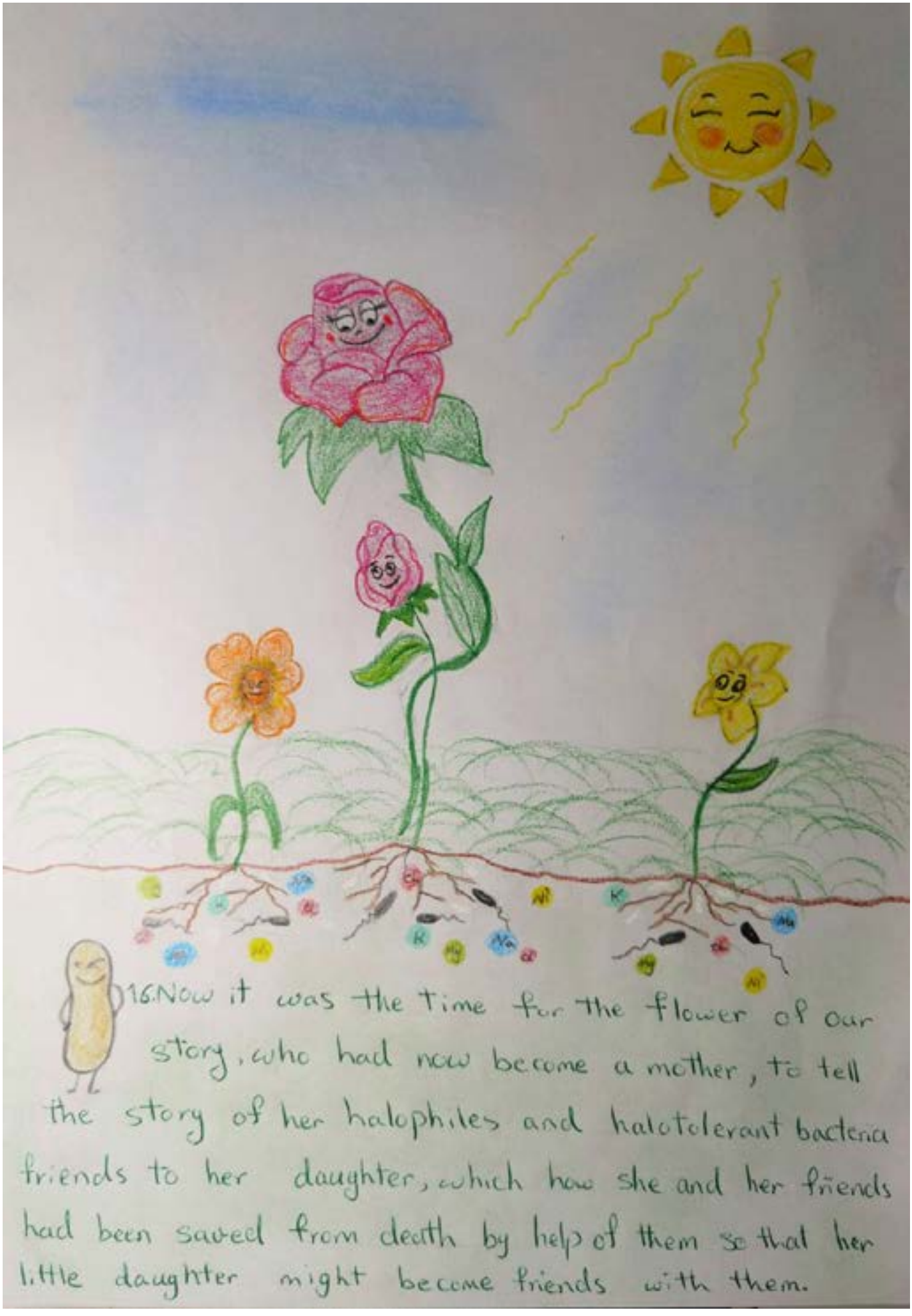
11. The first creature said: we are called sail indigenous and neutral bacteria and we are in this whole plain. We donot like the monster of salinity eather. Salinity kill us. The second said: we are called halotolerant bacteria and some of us who love salinity are called halophiles.

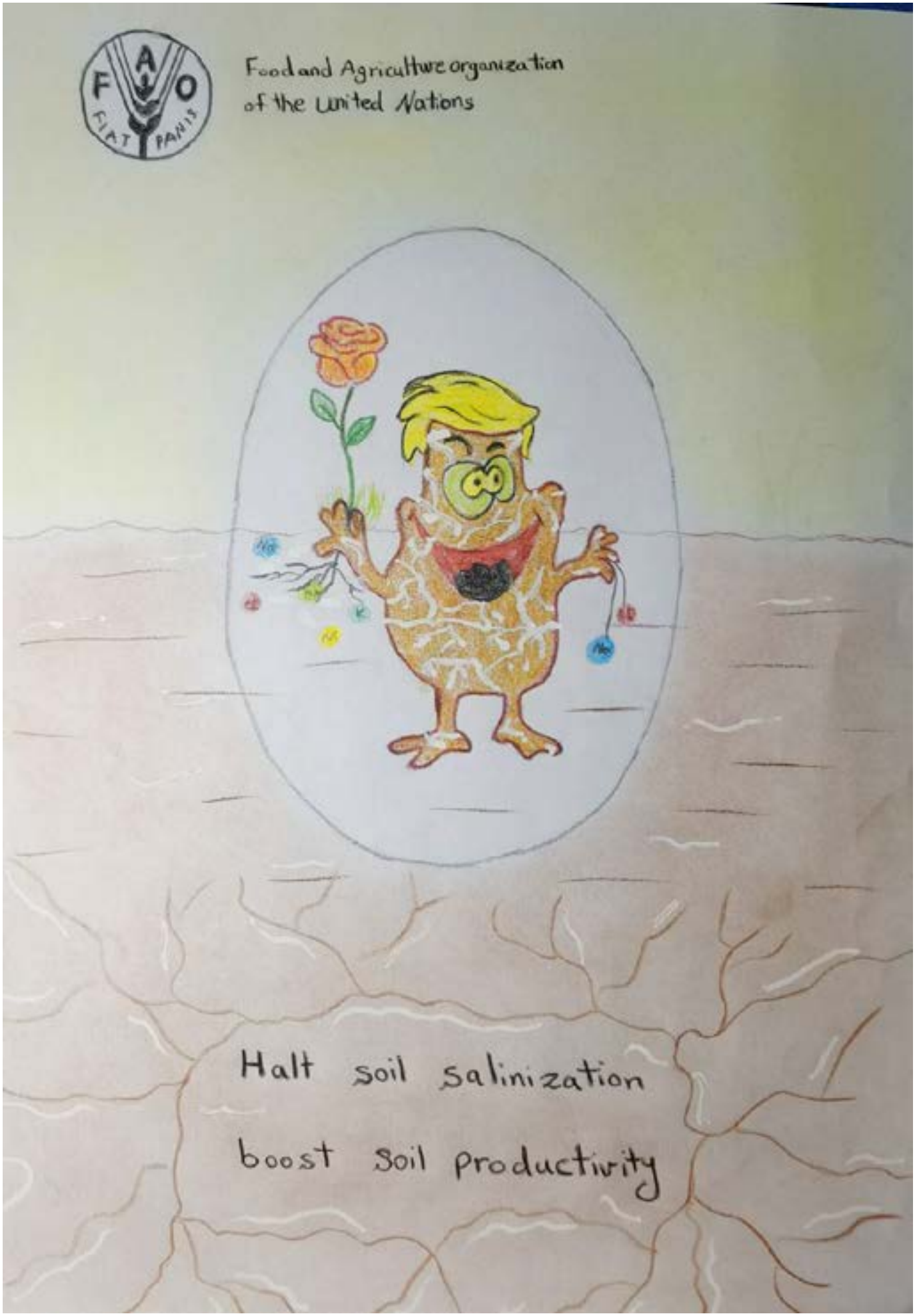
12 The little flower while surprised, asked again. You mean the salinity monster will not kill you? Bacteria said, with a laugh, NO, why kill? we are friends with monster and in fact, the monster is not a monster for us. In addition, my friend and I can help all flowers and trees like to resist the monster of salinity and not be afraid of him.

13. Really, Said the little Flower. Halotolerant bacteria Said: of course. You just have to let us gather around your roots to tack care of you. In addition, you can eat our food and we also use your food.

14. A few days later, only halophiles and halotolerant bacteria were gathered around the little flower roots and celebrated. There were all kinds of foods and all eat them.

15. After a while, the little flower was no longer small. She was big and beautiful. She saw that she and her friends were no longer dying of salinity monster.


16.Now it was the time for the flower of our story, who had now become a mother, to tell the story of her halophiles and halotolerant bacteria friends to her daughter, which how she and her friends had been saved from death by help of them so that her little daughter might become friends with them.


Food and Agriculture organization
of the United Nations
Halt soil salinization
boost soil productivity

Soil salinity in the classroom

Authors

Cristina Lull is a Spanish soil scientist of the Universitat Politècnica de València. Her passion is teaching soil sciences and the awareness of soil care among the young. She is in charge of the soil education and public awareness section of the Spanish Society of Soil Science. She enjoys observing nature and preparing activities and booklets to increase soil knowledge and care among young people.

Jose Manuel is a Spanish student of the Master's Degree in Environmental Engineering. He is convinced that the young need nature knowledge to look after the environment in which we live and for this, he creates visual materials for spreading nature care information. Together with Cristina, he has written a children's story and a children's booklet entitled "Join the global movement to restore the mother Earth" to promote SDG 15 (Life on Land) among the little ones.

"Halt soil salinization, Boost soil productivity"

Soil salinity in the classroom

This booklet aims at providing kids with advanced knowledge about soil salinity and its impacts.

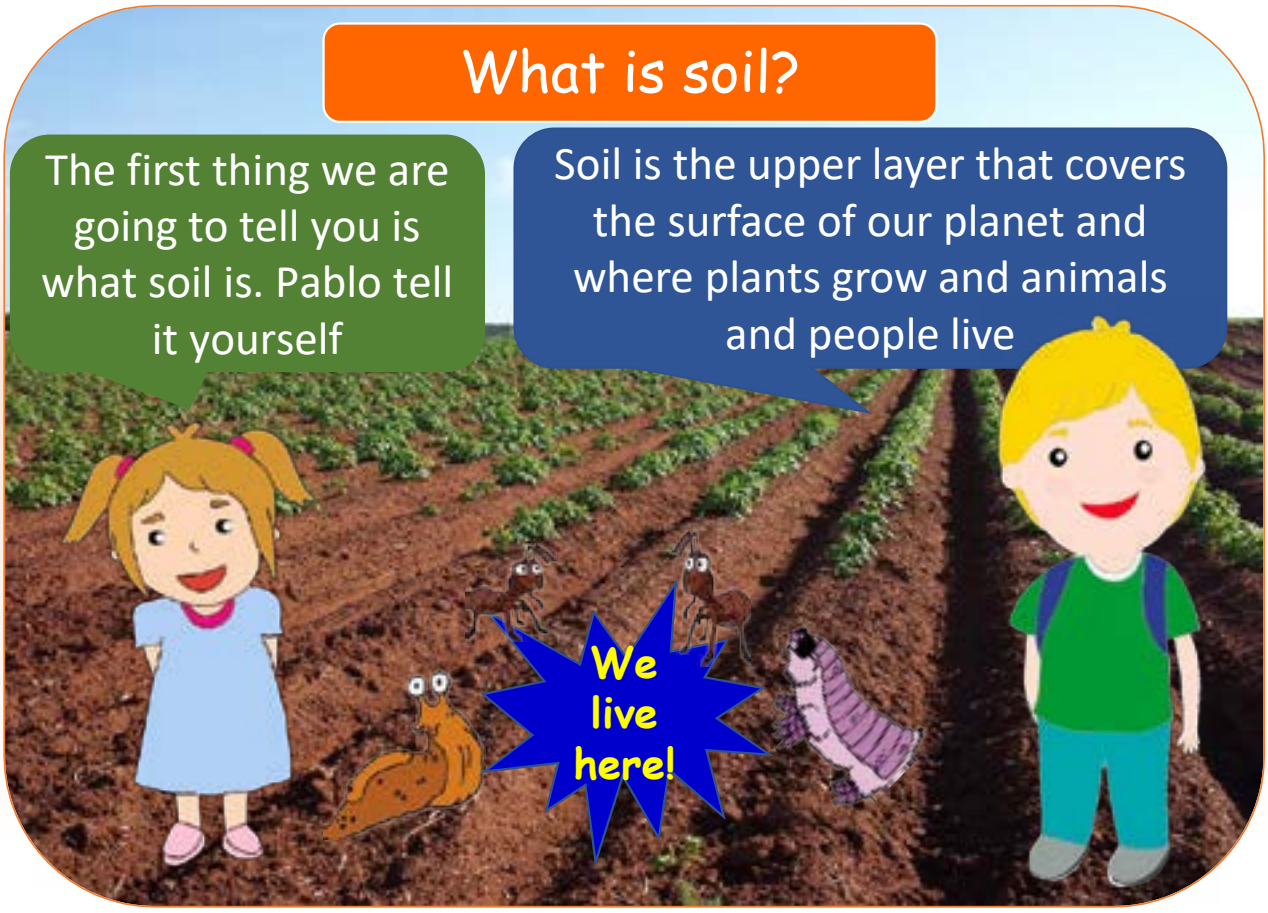
We hope that our work will be useful for

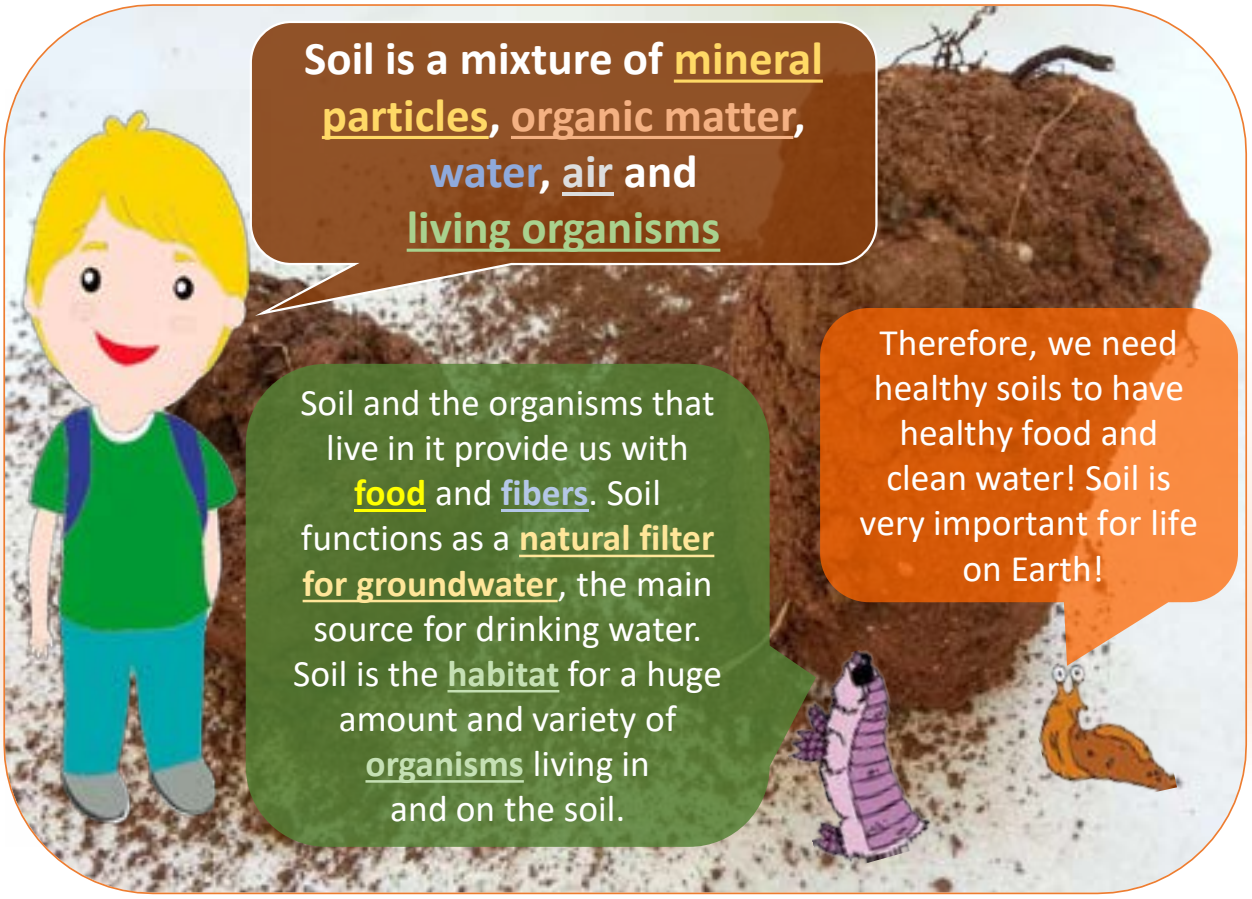
- understanding soil salinity
- being able to recognize risks of soil salinization
- being able to identify management options for preventing soil salinization


Before starting this adventure, we can introduce ourselves, and then begin to explain what soil salinization is.
Good idea !


I'm Claudia and he is my older brother, Pablo
Claudia and I always have a great time learning about nature. Have fun while learning more about soil!

What is soil?


The first thing we are going to tell you is what soil is. Pablo tell it yourself
Soil is the upper layer that covers the surface of our planet and where plants grow and animals and people live
We live here!


Soil is a mixture of mineral particles, organic matter, water, air and living organisms
Soil and the organisms that live in it provide us with food and fibers. Soil functions as a natural filter for groundwater, the main source for drinking water. Soil is the habitat for a huge amount and variety of organisms living in and on the soil.
Therefore, we need healthy soils to have healthy food and clean water! Soil is very important for life on Earth!

Is salt found in soil?

I like salty popcorn!

The answer is **YES**.
In the soil we can find salt minerals like halite, sylvite, anhydrite,
and many more

Halite is the mineral name for the substance that everyone knows as "table salt." Its chemical name is sodium chloride

In the photo you can see white salt crusts on the soil surface

Where does salt in the soil come from?

A soil may be rich in salts because the rock from which it was formed contains salts. During the process of chemical weathering of minerals and rocks, salts are gradually released and made soluble.

Chemical weathering occurs when water dissolves minerals in a rock, to form new minerals and soluble salts

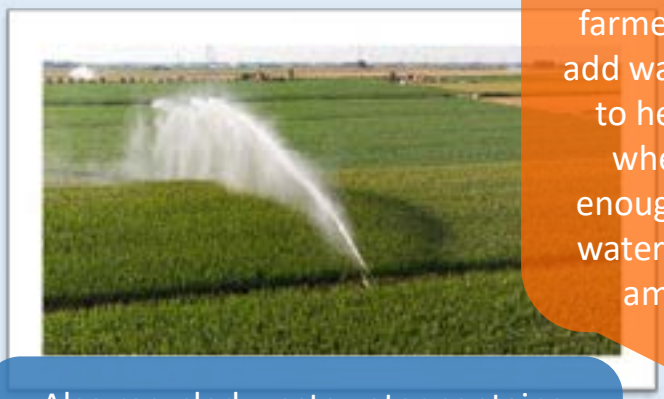
What is chemical weathering?

This is a natural cause of salt in soil

Salts can be carried from the sea water by strong winds and fall as rain across inland areas.
Salt concentration in rainfall is higher nearer to the coast.

In this case, the salt accumulates by natural phenomena

The two major sources of salts resulting from human activities are irrigation and fertilization

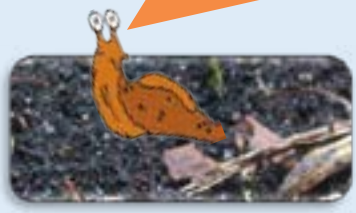


Irrigation is what farmers do when they add water to their fields to help plants grow when there is not enough rain. Irrigation water contains certain amount of salts.

Also recycled wastewater contains salts. Recycled wastewater generally refers to treated domestic wastewater that is used more than once.

Synthetic fertilizers, biosolids and compost also adds salts to soils

"**Synthetic fertilizers**" are materials containing one or more nutrients necessary for plant growth (e.g. nitrogen, phosphorus and potassium)



Compost is a type of fertilizer that is prepared by decomposing leaves, food waste, grass clippings, and other recycling organic materials. Compost is rich in plant nutrients.

What is soil salinization?

Soil salinization is an accumulation of soluble salts in the area where the roots of the plants grow, which causes negative effects

Soils that contain a harmful amount of salt are often referred to as salty or saline soils. Soil, or water, that has a high content of salt is said to have a high salinity.

These plants are healthy

This soil does not have large amounts of salts

Soil salinization is a serious soil degradation problem worldwide. Let's look at the negative effects

Soils with salinity problems present white crusts on the surface when the soil is dry. I don't like being on this soil

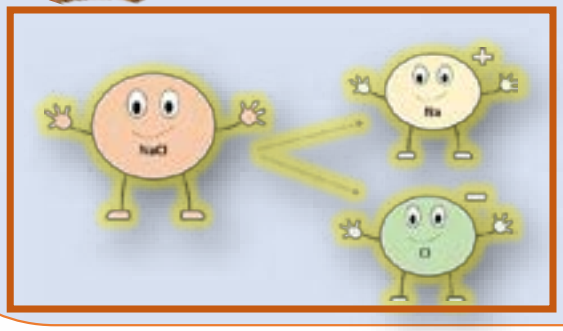
In addition to what the snail said, although the plants that grow in a saline soil have enough water, they show symptoms of a lack of water

Salts in the soil increase the efforts by plant roots to take in water

Another symptom that appears in plants when there are salinity problems is leaf necrosis. Necrosis due to salinization is when the edges of the leaves dry out and die.

Soil salinity can cause toxicity due to certain ions. The salt that we all know is made up of sodium (Na^+) and chloride (Cl^-) ions. Plants need these ions to grow but in excessive amounts they can be toxic. As we said at the beginning of the booklet , there are many other salts that can cause soil salinization.

If you don't know what an ion is, you should ask your teacher



Na^+ is beneficial to many species at lower levels in the water of the soils and toxic for many plants at high concentrations. Let's turn this topic into an experiment!

The effects of salt on seed germination

How does salt affect seed germination? Germination is the growth of a seed into a young plant.

Let's do an experiment to see what happens to the growth of seeds when salt is added

Materials

- 4 containers
- Kitchen paper or cotton wool roll
- Lentils/ wheat/alfalfa seeds
- Salt and 1 teaspoon
- Water and 4 glasses

Salt solutions

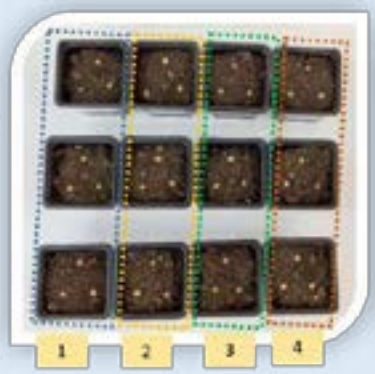
- Solution 1: Do not add any salt to the glass of water
- Solution 2: 1 glass of water with half a teaspoon of salt
- Solution 3: 1 glass of water with a teaspoon of salt
- Solution 4: 1 glass of water with two teaspoons of salt

Method

- Step 1. Number the 4 containers: 1 - 4
- Step 2. Dip four sheets of paper in each of the solutions and place two of them in the corresponding container
- Step 3. Place 6 seeds into each container
- Step 4. Cover the lentils with the other two sheets of paper with the corresponding solution
- Step 5. Cover the containers with transparent plastic

Watch the seed grow!

We can also do the experiment in pots. To do this, we will put soil in the pots. Then we will place the seeds on the soil. We will cover them with a thin layer of soil. Later we will water them with the same solutions that we have indicated before. Finally, we will cover them with a plastic bag.



Both experiments can take over 3 to 7 days and more

What happened to the seeds in each of the containers? Can you verify the following scientific concept "High concentrations of salt in the soil or water prevent seeds from germinating"

Observations

- ✓ Record the number of lentils that have sprouted
- ✓ Record the height of the lentils
- ✓ Analyse the results using an appropriate instrument (e.g. graph)

Halophytes or salt-loving plants

From previous experiments we have learned that there are plants that do not like large concentrations of salts in the soil

However, there are other plants that grow very well in soils with high concentrations of salts. They are called halophytes.

Halophyte

Limonium santapolense

How interesting!

Saline soils constitute natural ecosystems of great interest, characteristic of marshes, coastal plains and inland areas, in the latter case in arid and semi-arid environments

The conservation of these ecosystems is very important for the preservation of the environment

How can salinity problems be managed?

We can add enough low-salt water to the soil surface to dissolve the salts and move them below the root zone

You know a lot. As salts are soluble in water, when you add water to the soil, the salts will dissolve, as sugar dissolves in water, and will go down to deeper areas.

We need to remove salts from the plant root zone

Crop plants differ a great deal in their ability to survive when grown in saline soils. We can choose salt-tolerant crops.

We can plant crops or forages that are able to grow under moderate saline conditions

Search for information on whether potato and pea plants are salt-tolerant crops

We say goodbye. We hope you enjoyed this introduction to saline soils

With this booklet, we want to contribute to achieving the Sustainable Development Goals, including SDG 2 and 15.

SDG 2. Zero Hunger	SDG 15. Life on Land
Improve the quality of land and soil to end hunger.	Protect, restore, and promote sustainable use of terrestrial ecosystems.

Few plants grow well on saline soils. Therefore, salinization often restricts options for cropping in a given land area.

The ant and the snail have been designed by Francisco Javier Galán Onrubia

The Global Soil Partnership (GSP) is a globally recognized mechanism established in 2012. Our mission is to position soils in the Global Agenda through collective action. Our key objectives are to promote sustainable soil management (SSM) and improve soil governance to guarantee healthy and productive soils, and support the provision of essential ecosystem services towards food security and improved nutrition, climate change adaptation and mitigation, and sustainable development.

5 DECEMBER 2021

World Soil Day

Halt soil salinization, boost soil productivity

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