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The Energy-Passive Groundwater Recharge Product

The Energy-Passive Groundwater Recharge Product (EGRPÂ®) system could help with drought situations by recharging the groundwater table, stabilizing soil moisture content to improve agricultural conditions and preventing stormwater run off into the ocean.

The EGRPÂ® promotes surfaces infiltration and can increase the volume of water stored in the soil matrix. The EGRPÂ® works as a system engineered for the specific site at varying depths within a specific pattern. This site specific system joins separate soil layers, promoting connectivity across the soil matrix. This allows both mass water flow facilitated by gravity and diffuse water movement which is facilitated by negative pressure or suction.

For more information please see our attached documentation on the patented EGRPÂ® system, if you would like to read the executive summary of our research please contact us info@parjana.com.

Additional submitted attachment is included below.

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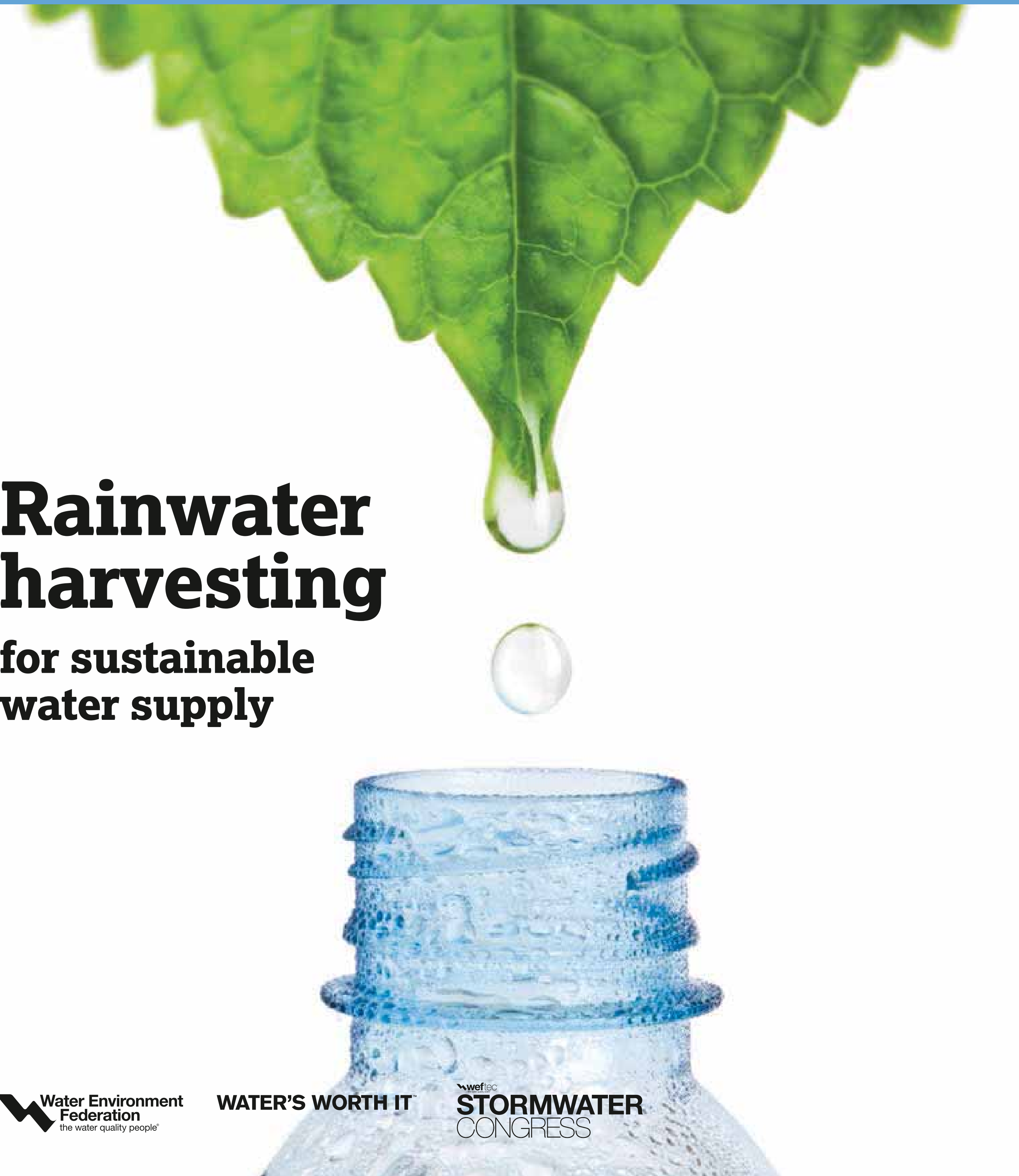

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Cover image A fresh tropical leaf with a drop of water above a glass bottle.
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Protecting watersheds through innovative drainage

The Energy-Passive Groundwater Recharge Product® is a new technology that can improve stormwater infiltration. Originally designed to promote drainage on sports fields and at private residences, it also can enhance the performance of green infrastructure and help reduce combined sewer overflows. **Donald Carpenter** of Lawrence Technological University and **Todd Houser** of DiGeronimo Aggregates LLC report on the technology's applications and how it works.

One of the root causes of the world's water woes is that development has dramatically altered the natural hydrologic cycle. Urbanization has increased the size and frequency of floods due to runoff generated by the built environment, which has simultaneously increased pollutant loadings and reduced groundwater recharge.

A typical natural forested watershed would generate about 10 percent surface runoff, while more than 50 percent of stormwater would infiltrate deep and shallow aquifers. However, extensive soil compaction and impervious surface cover greatly alters the site hydrograph, causing very limited infiltration and as much as 90 percent of rainfall volume ending up in runoff.

Aquifers also are reaching dangerously low levels from excessive pumping. In response to an increasingly dire situation, local, national, and even international organizations are calling for increasing sustainable watershed management practices.

In the urban environment, the design of stormwater systems can be very conservative – rightfully so, given the profession's commitment to protecting public health and safety. As such, the adoption of innovative methods for capture and treatment of stormwater can be slow.

Slow adoption is exacerbated by drainage ordinances that dictate the use of proven methods for managing stormwater. Further, many ordinances do not address the imbalanced urban water cycle or promote infiltration as a volume-reduction technique. The industry has an over-reliance on pipes and stormwater ponds, which may alleviate some flooding but do not always address water quality issues or groundwater recharge.

Improved drainage applications

In many areas, standing water can cause significant human health risks from water borne diseases. The Energy-Passive Groundwater Recharge Product® (EGRP) was invented by Andrew Niemczyk, partner with Parjana Distribution, to eliminate standing water near homes by drying out basements and yards and eliminating those hazardous situations. While it began as a homeowner drainage technology, the EGRP has found additional applications, such as draining athletic fields and golf courses.

Proper drainage and supplemental watering of athletic facilities is an expensive and time-consuming business. The several installations of the EGRP on golf courses and sports fields in the United States and United Kingdom have shown notable results. When installed on a youth league baseball field in the US state of Ohio, the field went from practically unusable to playable – even after heavy rainfall events. A 2014 assessment by the UK-based Sports Turf Research Institute on a cricket pitch with significant drainage issues showed that the pitch exhibited increased infiltration after the EGRP system was installed. The head groundskeeper indicated the pitch is now useable fter wet weather events, which was not the case before installation.

Additionally, the technology has been successfully installed at several airports in the United States and Europe to eliminate standing water that attracted nuisance birds, such as geese, which can be very hazardous on and near active runways.

The EGRP has now been installed at over 135 locations in three countries with a growing body of research documenting performance.

Green infrastructure applications

The expensive long-term solution to combined sewer overflows (CSOs) is to separate sanitary and storm sewers by installing new separate piping systems. In the near-term, urban areas are increasingly retrofitting communities with infiltration-based techniques for keeping untreated runoff from entering the sewer system in the first place. Increasingly common examples of green infrastructure practices that rely on infiltration for performance include rain gardens, bioswales, and porous pavement.

Infiltration is a critical design feature dependent both on the type of soil and the soil condition. Soil compaction is the enemy of sustainable landscaping practices. Therefore, it is important to minimize soil compaction during development, especially for soils underlying infiltration-based practices. Minimizing soil compaction also is important for vegetative establishment and growth. Dense soils will not promote optimum root growth and deep-rooted plants are excellent for promoting infiltration and evapotranspiration.

Before

After

Far left: A view of the partially flooded Edgbaston Cricket Ground practice field in Birmingham, England on March 13, 2014 – before EGRP installation.

Right: The Edgbaston Cricket Ground practice field in Birmingham, England on March, 14 2014 – after EGRP installation. The same part of the field was partially flooded from rains the day before installation.

Photo Credit: Groundwater Dynamics

INFILTRATION IS A CRITICAL DESIGN FEATURE DEPENDENT BOTH ON THE TYPE OF SOIL AND THE SOIL CONDITION.

Above: The top view of the Energy Groundwater Recharge Product. **Photo Credit: Andrew Niemczyk, EGRP inventor and partner with Parjana Distribution**

Because green infrastructure practices are dependent on underlying soils for performance, the use of EGRP systems to improve soil conditions and promote infiltration is an interesting application that needs further exploration.

To document how the EGRP system could assist in limiting CSOs, a 2014 investigation by Environmental Consulting and Technology, Inc. on an urban park in Detroit, Michigan, United States showed that the technology reduced volume of flow into the combined system by 63 percent over a three-month period when compared to a control site. The reduced flow volume represented more than 380 cubic meters of stormwater across a 10-hectare site. That stormwater would have been either treated at the wastewater treatment plant for a significant cost, or it could have triggered a CSO event and caused untreated sewage to flow into the nearby Detroit River.

Compared to the adjacent control site, research data also indicated that there was no measurable effect on groundwater levels in the zone with EGRPs installed. This suggests stormwater that previously flowed into the combined system is now being stored in the near-surface soil pore space.

Ultimately, increased surface infiltration will promote groundwater recharge, but that appears to be a longer-term process. An investigation conducted by Michigan State University researchers at the Coleman Young Airport in Detroit showed the EGRP improved the movement of water in the downward direction. It did not, however, overly accelerate the flow of contaminants vertically.

The vertical movement of contaminants into the groundwater is a concern of regulatory agencies that fear this technology acts like a vertical drain or conduit. Results from the investigation, however, suggest contaminants are not directly moving from surface water to the groundwater. This is an area that needs further exploration.

Another area for further research is the use of EGRP in agricultural areas. There are significant issues – among them serious algal blooms – with agricultural runoff and its high nutrient loads. If the EGRP could balance soil moisture, promoting healthy root growth while limiting surface runoff, it could replace traditional drainage tile systems and limit the amount of supplemental watering and fertilization required by crops. Combining the EGRP with expanded shale – which has high-flow, phosphorus-sorption, and plant growth benefits – holds promise for soil and water quality improvements. Soil scientists and agricultural engineers are just beginning to investigate this application.

How it works

To understand how the EGRP works, it is important to understand water movement in soil. The EGRP is a patented technology that manages surface water and groundwater by addressing the nuanced nature of water's movement through soil.

The EGRP is a five-chamber, extruded hydrophobic polyethylene plastic tube, with open channels along the edges to facilitate movement of water. Generically, the EGRP can be classified as a vertical capillary-driven drainage device, but in reality, it is more complex than most vertical drainage systems.

In a typical installation, the top of the EGRP is positioned 60 centimeters below the soil surface and continues down for depths between 1.5 to 6 meters. Multiple EGRP devices are installed in groups across an area in a pattern designed for the particular application.

The pattern allows the EGRP to join separate soil layers and promotes connectivity across the soil matrix, allowing both mass flow and diffuse water movement. The EGRP promotes surface infiltration, and it increases the volume of stormwater that can be infiltrated and stored in the soil matrix by balancing soil-water potential across the vertical and horizontal soil strata in the vadose (unsaturated) zone. This

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functionality corresponds to improved connectivity between macropores. This connectivity between macropores is necessary for mass flow of free water that is unaffected by soil-water tension, which is negative pressure or suction. Improved connectivity between smaller pores is also essential to diffuse water movement under tension.

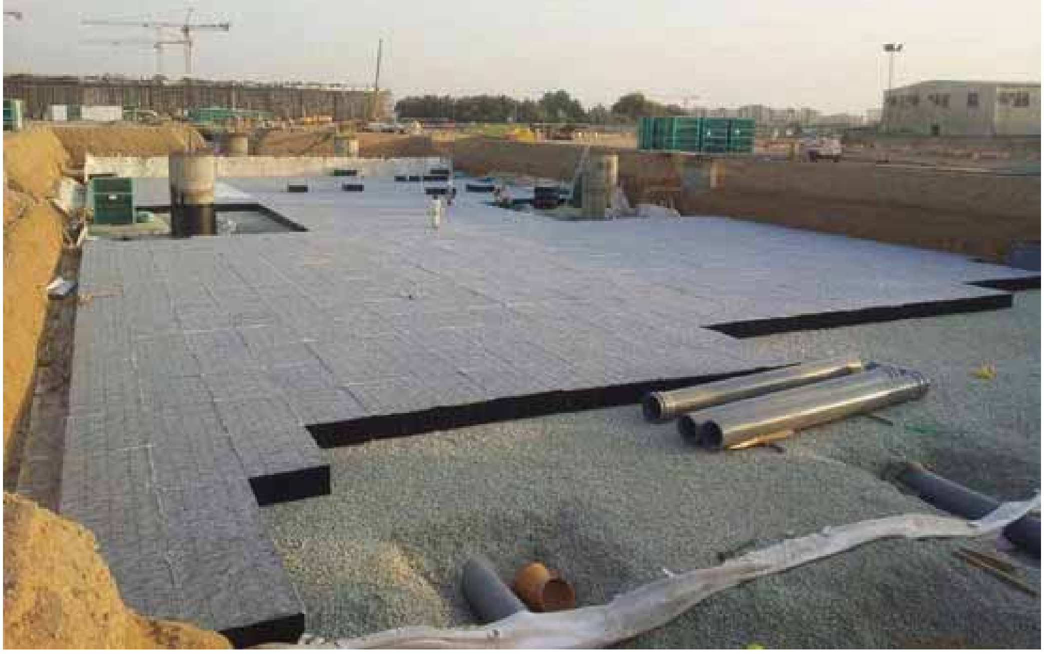
Water state condition in the vadose zone can change significantly, at least seasonally, from dry (greater than 1500 kilopascal of tension), to wet (less than 1.0 to greater than 0.0 kilopascal), and to wet-satiated (less than 0.0 kilopascal of tension). So, improved connectivity between macropores and smaller pores is beneficial to overall water regulation – including infiltration, storage, deep percolation, evapotranspiration, and more. While improved downward, free-water flow due to the force of gravity is critical for improved volume reduction and groundwater recharge, the upward movement of soil-water under tension is necessary to the supply of plant-available water and evapotranspiration losses during summer months and periods of drier water-state conditions.

The EGRP represents an innovative approach to managing stormwater runoff in a practical way, in a variety of settings. While research has not positively concluded the performance of the system in all soil conditions or settings, the EGRP has been documented to perform remarkably well in many situations. The performance of this system, and others, needs to be documented and disseminated to advance innovation in stormwater management.

Authors' Note

Donald Carpenter is a professor of Civil Engineering and director of the Great Lakes Stormwater Management Institute at Lawrence Technological University in Southfield, Michigan. Carpenter also is a professional engineering and practicing green design professional.

Todd Houser is a technical sales representative and soil physicist for DiGeronimo Aggregates LLC, a national industry leader in the production of a lightweight expanded shale aggregate, Haydite. Houser has a Master of Science in Soil Physics and has served as auxiliary faculty in soil management for Ohio State's Agricultural Technical Institute.



Water flow and storage solutions in dry climates

Stormwater drainage systems using vortex flow control and geocellular storage technology were installed to help manage large volumes of stormwater with high concentrations of grit and sand for high-speed rail stations in both Jeddah and King Abdullah Economic City in the Middle East. **Clive Evans** of Hydro International explains.

Jeddah's devastating flash floods in November 2009 shocked the world. The deluges in the Saudi Arabian coastal city caused chaos and destruction at the height of Hajj, the annual Islamic pilgrimage season. At least 120 people died when 90 millimeters of rain fell in less than 24 hours – twice the region's average for an entire year.

The sheer intensity of the rainfall in an otherwise arid climate was a clear outcome, many believe, of climate change. Cars were swept up in almost one meter of fast-moving water and deposited in ugly piles as the water receded. There were repeated floods in following years.

Rapid economic growth, ambitious infrastructure investment, and huge population expansion are overwhelming the existing stormwater network in Saudi Arabia – a common situation in many Middle East countries today.

Infrastructure investment continues rapidly across the region. Development is now being matched by multi-million dollar funding to build storm drains and improve the stormwater and foul water networks.

Combining local knowledge with the best in civil engineering and planning expertise from across the globe, far-reaching drainage measures are planned to prevent repeated disasters. Such measures are essential – not just to protect lives and livelihoods, but also the valuable new developments themselves as many flagship and iconic buildings are linked with major new world-class road and rail projects.

To address storm drainage infrastructure, governments can turn to developing international disciplines such as sustainable urban drainage systems (SuDS), low impact development (LID), and water sensitive urban design (WSUD). But with so many technologies originally designed for more temperate regions, it's important to track down the best solutions to deal with the unique challenges of an arid climate, specifically large quantities of fast-flowing water and high concentrations of suspended grits and sand.

Water storage for railway project

One example can be found in the construction of the 449.2-kilometers, high-speed Al Haramain railway, which links the Muslim holy cities of Medina and Mecca via King Abdullah Economic City, Rabigh, Jeddah, and King Abdulaziz International Airport. It is one of Saudi Arabia's most prestigious and far-reaching infrastructure projects.

Each of the railway's four main stations blends modern and traditional Islamic designs, with shops, restaurants, mosques, car parking, and a helipad.

The water and drainage systems