KEMENTERIAN SAINS, TEKNOLOGI DAN INOVASI
MINISTRY OF SCIENCE TECHNOLOGY AND INNOVATION

NUKLEAR MALAYSIA

TARIKH	11 MEI 2026 (ISNIN)	**SURATKHABAR**	BH / UM / NST / TS / HM / KOSMO
TAJUK ARTIKEL	THESE FABRICS ARE REALLY, REALLY SMART		
M/S	6 (ECOWATCH)	**KATA KUNCI**	TEXTTILES, ELECTROGENIC
BIDANG	SCIENCE AND TECHNOLOGY	TEXTILES	

These **fabrics** are really, really **smart**

Electrogenic textiles contain bacteria that can break down waste and produce clean energy.

India's textile industries produce millions of litres of wastewater daily. Smart fabrics can help clean that up, and produce electricity too. – IGOR OVSYANNYKOV/Wikimedia Commons

By RAHUL KANDPAL, DR ZA SHAIKH and DR S. WAZED ALI

TEXTILE industries, the backbone of India's economy, produce millions of litres of wastewater daily, laden with toxic dyes and organic pollutants such as methylene blue and Congo red.

These dyes block sunlight, hindering photosynthesis in aquatic plants and depleting dissolved oxygen, leading to "dead zones" where fish and other aquatic life cannot survive. Many of these synthetic dyes are also carcinogenic and mutagenic, and they seep into the groundwater and enter the food chain.

Traditional methods of cleaning water, such as activated sludge or advanced oxidation processes, are often energy-intensive and expensive. These systems require massive amounts of electricity to supply the oxygen needed to help waste-eating bacteria break down pollutants.

Turning this environmental burden into a source of clean energy would be a game-changer. One path towards this lies in merging advanced materials – such as microfibres, carbon nanotubes, and conducting polymers – with the power of nature's smallest workers, bacteria, to create a flexible, fabric-based system that not only cleans wastewater but also generates electricity.

The researchers began by using a polyester microfibre nonwoven fabric made from waste PET plastic bottles. Similar to high-tech industrial fabrics such as those used in smart wearable electronics and specialised industrial filtration, it integrates carbon nanotubes (CNTs) and a conductive polymer called polyaniline (pani).

CNTs provide a large surface area for transporting electrons, like cars speeding on a highway. But speeding cars need bridges to get onto highways, and pani acts like bridges to help the electrons attach securely to the CNTs.

The cleaning star is specialised bacteria known as exoelectrogens. Unlike typical germs, these microbes have the unique ability to "breathe" out electricity. As they consume organic pollutants, they release electrons which are captured by the fabric and turned into a steady stream of power.

A massive surface area enables more space for bacteria to attach, form dense biofilms, and increase the rate at which they consume pollutants. High conductivity, enabled by the CNTs and pani, ensures electrons released by these microbes are captured and transported efficiently.

Pani is hydrophilic – loves water – and biocompatible, two qualities that help the bacteria transfer the electrons produced as a bioproduct of the clean-up job more easily. Together, these properties allow the textile to generate nearly 2,000 times more electricity than normal materials, even as it effectively cleans wastewater.

The team discovered that what helps electrogenic (electricity-generating) textiles raise their "power quotient" is a specific, uncultured strain of dye-degrading bacteria called *Lysinibacillus* – this strain naturally dominated electrogenic textiles. *Lysinibacillus* bacteria are biological marvels: They grow tiny, conductive "nano wires" and secrete redox molecules that act like microscopic power lines, shuttling electrons from their bodies to the fabric on which they lie with incredible efficiency.

Treating wastewater is challenging, given the high costs and the polluting by-products of the process. Smart textiles with high surface area and conductivity can be scalable options in solving the problem.

The latest experiment used several pieces of these textiles as electrodes in a reactor designed to produce electricity from polluted water, even as it was cleaned. Each piece of fabric is coated with slightly different materials to attract various electrogenic microbes.

The experiment had very promising results: Besides doing the main job of removing over 82% of harmful dyes from wastewater, this reactor was able to remove about 86% percent of the chemical oxygen demand (COD).

COD is a key indicator of the level of pollutants present in wastewater; it tells us how much oxygen would be required to chemically break down contaminants. A large reduction in COD suggests a substantial improvement in water quality.

Unlike conventional wastewater treatment systems which consume large amounts of electricity, this reactor produced enough electrical power to potentially offset part of its own operating needs. In other words, instead of using energy to clean water, the system can recover energy from wastewater.

The microbes also produced useful chemical byproducts during the treatment process. One of these was malonic acid, an industrially-valuable compound used in manufacturing pharmaceuticals, perfumes, and specialty plastics.

The textile-based electrodes are flexible, inexpensive, and easy to manufacture in large surface areas. More importantly, the experiments used real industrial wastewater rather than carefully prepared laboratory solutions, bringing the technology closer to practical, real-world use.

With industrial growth urgently needing to be balanced with environmental preservation, electrogenic fabrics offer a viable solution. Their flexible, scalable nature means they can be adapted to various reactor designs, from small-scale units for local dyers to large industrial treatment plants.

By looking at wastewater not as a problem to be discarded into the rivers but as a resource to be harvested, we can move towards a truly circular economy. The clothes we wear pollute our waterways, but through this smart fabric technology, the waste from their production could help power a cleaner, greener tomorrow. – 360info

The authors are from the Indian Institute of Technology: Rahul Kandpal is a PhD candidate at the School of Interdisciplinary Research, Prof Dr ZA Shaikh is with the Department of Biochemical Engineering, and Prof Dr S. Wazed Ali is with the Department of Textile and Fibre Engineering.