

Is Fukushima wastewater release safe? What the science says

福岛污水排放安全吗？科学是怎么说的

Radiation in the water will be diluted to almost-background levels, but some researchers are not sure this will be sufficient to mitigate the risks.

水中的辐射将被稀释到接近本底水平，但一些研究人员不确定这是否足以减轻风险。

Despite the concerns of several nations and international groups, Japan is pressing ahead with plans to release into the Pacific Ocean water contaminated by the 2011 meltdown of the Fukushima Daiichi nuclear power plant. Sometime this year, Japan will start a 30-year process of slowly releasing treated water stored in tanks at the site into the ocean through a pipeline extending one kilometre from the coast. But just how safe is the water to the marine environment and humans across the Pacific region?

尽管一些国家和国际组织对此表示担忧，但日本仍在推进向太平洋排放受 2011 年福岛第一核电站（Fukushima Daiichi）熔毁而受污染的水的计划。今年的某个事件，日本将启动一个为期 30 年的过程，通过一条从海岸延伸一公里的管道，将储存在核电站水箱中的处理过的水缓慢排放到海洋中。但排放的水对太平洋地区的海洋环境和人类到底有多安全呢？

How is the water contaminated?

水是怎么被污染的？

Several explosions occurred at the power station after a devastating earthquake and subsequent tsunami damaged the coastal plant, overheating the reactor cores. Since then, more than 1.3 million cubic metres of seawater have been sprayed onto the damaged cores to keep them from overheating, contaminating the water with 64 radioactive elements, known as radionuclides. Of greatest concern are those that could pose a threat to human health: carbon-14, iodine-131, caesium-137, strontium-90, cobalt-60 and hydrogen-3, also known as tritium.

毁灭性的地震和随后的海啸破坏了这座沿海核电站，导致反应堆堆芯过热，核电站发生了几次爆炸。从那时起，超过 130 万立方米的海水被喷洒到受损的堆芯上，以防止它们过热，这些海水被 64 种放射性元素污染，这些放射性元素又被称为放射性核素。最令人担忧的是那些可能对人类健康构成威胁的物质：碳-14、碘-131、铯-137、锶-90、钴-60 和氢-3（也被称为氚）。

Some of the radionuclides have a relatively short half-life and will already have decayed in the 12 years since the disaster. But others take longer to decay; carbon-14, for example, has a half-life of more than 5,000 years.

一些放射性核素的半衰期相对较短，在灾难发生后的 12 年里已经衰变。但另一些则需要更长时间才能衰变；例如，碳-14 的半衰期超过 5000 年。

How is the water being treated?

这些污水是如何处理的？

The contaminated water has been collected, treated to reduce the radioactive content and stored in more than 1,000 tanks at the site. The power-station operator, Tokyo Electric Power Company (TEPCO), has used what it describes as an advanced liquid-processing system (ALPS) to treat the water. TEPCO says the water undergoes five processing stages of co-sedimentation, adsorption and physical filtration.

受污染的水已被收集起来，经过处理以降低放射性含量，并储存在核电站的 1000 多个水箱中。电站运营商东京电力公司（TEPCO）使用了一种多核素去除设备（ALPS）来处理这些污水。东京电力公司说，这些污水会经过共沉积、吸附和物理过滤五个处理阶段。

The ALPS process removes enough of 62 of the 64 radionuclides to bring their concentration below Japan's 2022 regulatory limits for water to be discharged into the environment. These limits are based on recommendations from the International Commission on Radiological Protection.

ALPS 过程去除了 64 种放射性核素中的 62 种，使其浓度低于日本 2022 年的监管限值，从而将这些废水排放到环境中。这些限值是基于一国际放射防护委员会（International Commission on Radiological Protection）的建议。

But that process does not remove carbon-14 and tritium, so the treated water needs to be diluted. TEPCO says that the resulting concentration of tritium is around 1,500 becquerels (a measure of the radioactivity of a substance) per litre — around one-seventh of the World Health Organization's guidelines for tritium in drinking water. The company suggests that the concentration of tritium will drop to background ocean levels within a few kilometres of the discharge site. The carbon-14 in the tanks is currently at concentrations of around 2% of the upper limit set by regulations, TEPCO says, and this will reduce further with the seawater's dilution.

但是这个过程不能去除碳-14 和氚，所以处理后的水需要稀释。东京电力公司表示，由此产生的氚浓度约为每升 1500 贝可勒尔（一种测量物质放射性的方法）——大约是世界卫生组织饮用水中氚含量标准的七分之一。该公司表示，在排放地点几公里范围内，氚的浓度将降至海洋本底水平。东京电力公司表示，储水箱中的碳-14 目前的浓度约为规定上限的 2%，随着海水的稀释，这一浓度将进一步降低。

Jim Smith, an environmental scientist at the University of Portsmouth, UK, says the risk this poses to nations around the Pacific Ocean will probably be negligible. "I always hesitate to say zero, but close to zero," he says. "The nearest Pacific island is about 2,000 kilometres away." He argues that a greater risk is posed by keeping the treated water on-site. "The risk of another earthquake or a typhoon causing a leak of a tank is higher."

英国朴茨茅斯大学（University of Portsmouth）的环境科学家吉姆·史密斯（Jim Smith）说，这对太平洋沿岸国家构成的风险可能可以忽略不计。“我一直不太想说风险是零，但接近零，”他说。“最近的太平洋岛屿也在 2000 公里之外。”他认为，将处理过的水留在核电站会带来更大的风险。“再次发生地震或台风而导致水箱泄漏的风险更高。”

Will radioactivity be concentrated in fish?

放射性物质会富集在鱼身上吗？

Nations such as South Korea have expressed concern that the treated water could have unexplored impacts on the ocean environment, and a delegation from the country visited the Fukushima site in May. Last year, the US National Association of Marine Laboratories in Herndon, Virginia, also voiced its opposition to the planned release, saying that there was “a lack of adequate and accurate scientific data supporting Japan’s assertion of safety”. The Philippine government has also called for Japan to reconsider its plan to release the water into the Pacific.

韩国等国家对处理后的水可能对海洋环境产生未知的影响表示担忧，该国的一个代表团于 5 月访问了福岛核电站。去年，位于弗吉尼亚州赫恩登(Herndon)的美国国家海洋实验室协会 (US National Association of Marine Laboratories)也表达了对排核放计划的反对，称“缺乏足够和准确的科学数据支持日本的安全主张”。菲律宾政府还呼吁日本重新考虑将污水排入太平洋的计划。

“Have the people promoting this ... demonstrated to our satisfaction that it will be safe for ocean health and human health?” asks Robert Richmond, a biologist at the University of Hawaii at Manoa. “The answer is ‘no’.”

“推广这项计划的人.....是否已经向我们证明，它对海洋健康和人类健康是安全的？”夏威夷大学马诺阿分校的生物学家罗伯特·李察曼问道。“答案是‘没有’。

Richmond is one of five scientists on a panel advising the Pacific Islands Forum, an intergovernmental organization made up of 18 Pacific nations, including Australia, Fiji and Papua New Guinea. The panel was convened to advise on whether the release of the treated water from Fukushima was safe both for the ocean and for those who depend on it. Richmond says that the panel has reviewed all the data provided by TEPCO and the Japanese government, and visited the Fukushima site, but that there are still some unanswered questions about tritium and carbon-14.

李察曼是太平洋岛屿论坛顾问小组的五位科学家之一。太平洋岛屿论坛是一个由 18 个太平洋国家组成的政府间组织，包括澳大利亚、斐济和巴布亚新几内亚。召集该小组是为了就从福岛排放处理过的水对海洋和依赖海洋的人是否安全提出建议。李察曼说，该小组审查了东京电力公司和日本政府提供的所有数据，并访问了福岛核电站，但关于氚和碳-14 仍有一些未解之谜。

Tritium is a β -radiation emitter — albeit a weak one — meaning that it emits ionizing radiation that can damage DNA. “If you eat something that’s radioactively contaminated with β -emitters, your cells inside are being exposed,” says Richmond.

氚是一种 β 辐射发射体--尽管很微弱--这意味着它发出的电离辐射会损伤 DNA。“李察曼说：“如果你吃了某种被 β 辐射体污染的东西，你体内的细胞就会受到辐射。”

TEPCO says fishing is not routinely conducted in an area within 3 kilometres of where the pipeline will discharge the water. But Richmond is concerned the tritium could concentrate in the food web as larger organisms eat smaller contaminated ones. “The very chemistry of dilution is undercut by the biology of the ocean,” Richmond says.

东京电力公司表示，在管道排水口 3 公里以内的区域，平时都没有捕鱼活动。但李察曼担心，当较大的生物吃掉较小的受污染生物时，氚可能会在食物网中富集。李察曼说：“海洋的生物特性削弱了稀释的化学作用。”

Shigeyoshi Ootosaka, an oceanographer and marine chemist at the Atmospheric and Ocean Research Institute of the University of Tokyo says that the organically bound form of tritium could accumulate in fish and marine organisms. "I think it is important to evaluate the long-term environmental impact of these radionuclides," Ootosaka says.

东京大学大气与海洋研究所的海洋学家和海洋化学家大坂茂吉(Shigeyoshi Ootosaka)说，有机结合形式氚可能会在鱼类和海洋生物中积累。“我认为评估这些放射性核素对环境的长期影响是很重要的，”Ootosaka 说。

A spokesperson for TEPCO said that the company has raised marine organisms in seawater containing ALPS-treated water. "The tritium concentrations in the bodies of marine organisms reach equilibrium after a certain period of time and do not exceed the concentrations in the living environment," the spokesperson said. Tritium concentrations then decrease once the organism is returned to untreated seawater.

东京电力公司发言人说，该公司已在含有 ALPS 处理水的海水中饲养了海洋生物。“发言人说：“海洋生物体内的氚浓度在一段时间后达到平衡，不会超过生活环境中的浓度。一旦生物体被放回到未经处理的海水中，氚浓度就会降低。

TEPCO will continue to compare the health of organisms reared in diluted treated water with those reared in seawater.

东京电力公司将继续比较在稀释处理过的水中饲养的生物与在海水中饲养的动物的健康状况。

Has this been done before?

此事可有先例？

Smith points out that releasing tritium-contaminated water is common for nuclear power plants. He says that, in the United Kingdom, both the Heysham nuclear power station and the Sellafield nuclear-fuel-processing plant in release between 400 and 2,000 terabecquerels of tritium into the ocean each year.

史密斯指出，核电站释放受氚污染的水是很常见的。他说，在英国，希舍姆核电站和塞拉菲尔德核燃料处理厂每年都会向海洋释放 400 到 2000 太贝克勒尔的氚。

Ootosaka says that this is also the case in Japan: "More than 50 terabecquerel of tritium was discharged annually from each nuclear power plant in regular operation before the accident," he says. TEPCO says that less than 22 terabecquerels of tritium will be released from the pipeline each year.

大阪说，日本的情况也是如此：“他说：“事故发生前，每座正常运行的核电站每年排放的氚超过 50 太贝克勒尔。东京电力公司表示，每年从管道中排放的氚将少于 22 太贝克勒尔。

The International Atomic Energy Agency, which has been supervising the clean-up and

management of Fukushima, is expected to release a final report on the site and the plan for the wastewater soon.

一直在监督福岛核电站清理和管理工作的国际原子能机构(International Atomic Energy Agency)预计将很快发布一份关于核电站选址和污水处理计划的最终报告。

By Bianca Nogrady