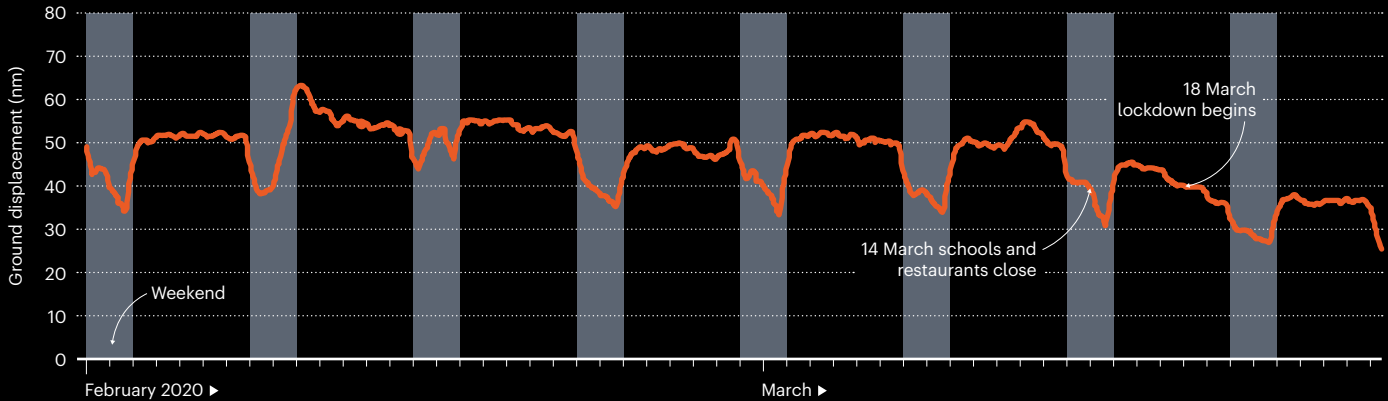




**SEISMIC NOISE**

In Belgium, vibrations caused by human activity have fallen by about one-third since coronavirus containment measures were introduced.



SOURCE: ROYAL OBSERVATORY OF BELGIUM

**Coronavirus lockdowns have changed the way Earth moves**

The coronavirus pandemic has brought chaos to lives and economies around the world. But efforts to curb the spread of the virus might mean that the planet itself is moving a little less. Researchers who study Earth's movement are reporting a drop in seismic noise — the hum of vibrations in the planet's crust — that could be the result

of transport networks and other human activities being shut down. They say this could allow detectors to spot smaller earthquakes and boost efforts to monitor volcanic activity.

A noise reduction of this magnitude is usually experienced only around Christmas, says Thomas Lecocq, a seismologist at the Royal Observatory of Belgium in Brussels, where the drop was observed.

Just as natural events such as earthquakes cause Earth's crust to move, so do vibrations caused by moving vehicles and industrial machinery. And although the effects from individual sources might be small, together they produce background noise, which reduces seismologists' ability to detect other signals occurring at the same frequency.

Data from a seismometer at the observatory show that measures to curb the spread of COVID-19 in Brussels caused human-induced seismic noise to fall by about one-third, says Lecocq. The measures included closing schools, restaurants and other public venues, and banning all non-essential travel (see 'Seismic noise').

The drop has boosted the sensitivity of the observatory's equipment, improving its ability to detect waves in the same high-frequency range as the noise. The facility's surface seismometer is now almost as sensitive to small quakes and quarry blasts as a detector buried in a 100-metre borehole, Lecocq says.

If lockdowns continue in the coming months, city-based detectors worldwide

**HOW SEWAGE COULD REVEAL TRUE SCALE OF CORONAVIRUS OUTBREAK**

Wastewater testing could also be used as an early-warning sign if the virus returns.

By Smriti Mallapaty

**M**ore than a dozen research groups worldwide have started analysing waste water for the new coronavirus as a way to estimate the total number of infections in a community, given that most people will not be tested. The method could also be used to detect the coronavirus if it returns to communities, say scientists. So far, researchers

have found traces of the virus in sewage in the Netherlands, the United States and Sweden.

Analysing waste water — used water that goes through the drainage system to a treatment facility — is one way that researchers can track infectious diseases that are excreted in urine or faeces, such as SARS-CoV-2.

One treatment plant can capture waste water from more than one million people, says Gertjan Medema, a microbiologist at KWR Water Research Institute in Nieuwegein, the

Netherlands. Monitoring influent at this scale could provide better estimates for how widespread the coronavirus is than testing, because wastewater surveillance can account for those who have not been tested and have only mild or no symptoms, says Medema, who has detected SARS-CoV-2 genetic material — viral RNA — in several treatment plants in the Netherlands.

But to quantify the scale of infection in a population from wastewater samples, researchers say the groups will need to find out how much viral RNA is excreted in faeces, and extrapolate the number of infected people in a population from concentrations of viral RNA in wastewater samples.

Researchers will also need to ensure that they are looking at a representative sample of what is being excreted by the population and not just one snapshot in time, and that their tests can detect the virus at low levels, say scientists representing the Queensland Alliance for Environmental Health Sciences in Australia, which advises the state government

might be better than usual at detecting the locations of earthquake aftershocks, says Andy Frassetto, a seismologist at the Incorporated Research Institutions for Seismology in Washington DC. “You’ll get a signal with less noise on top, allowing you to squeeze a little more information out of those events,” he says.

The fall in noise could also benefit seismologists who use naturally occurring background vibrations, such as those from crashing ocean waves, to probe Earth’s crust. Because volcanic activity and changes to water tables affect how fast the natural waves travel, scientists can study these processes by monitoring how long it takes a wave to reach a given detector. A fall in human-induced noise could boost the sensitivity of detectors to natural waves at similar frequencies, says Lecocq.

Belgian seismologists are not the only ones to notice the effects of lockdown. Celeste Labeledz, a graduate student in geophysics at the California Institute of Technology in Pasadena, tweeted that a “seriously wild” fall in noise had been picked up by a station in Los Angeles.

But not all seismic monitoring stations will see such a pronounced effect, says Emily Wolin, a geologist at the US Geological Survey in Albuquerque, New Mexico. Many stations are purposefully located in remote areas or deep boreholes to avoid human noise. These should see a smaller decrease, or no change at all, in the level of high-frequency noise they record.

Elizabeth Gibney

on environmental-health risks.

Infection-control measures, such as social distancing, will probably suppress the current pandemic, but the virus could return once such measures are lifted. Routine wastewater surveillance could be used as a non-invasive early-warning tool to alert communities to new COVID-19 infections, says Ana Maria de Roda Husman, an infectious-disease researcher at the Netherlands National Institute for Public Health and the Environment in Bilthoven. The institute has previously monitored sewage to detect outbreaks of norovirus, antibiotic-resistant bacteria, poliovirus and measles.

de Roda Husman’s group detected traces of SARS-CoV-2 in wastewater at Schiphol airport in Tilburg, the Netherlands, only four days after the country confirmed its first case of COVID-19 using clinical testing. The researchers now plan to expand sampling to the capitals of all 12 provinces in the Netherlands and 12 other sites that have not had any confirmed cases.

# MATHS PROOF THAT ROCKED NUMBER THEORY WILL BE PUBLISHED

But some experts say author Shinichi Mochizuki failed to fix fatal flaw in solution to major problem.

By Davide Castelvecchi

**A**fter an eight-year struggle, embattled Japanese mathematician Shinichi Mochizuki has finally received some validation. His 600-page proof of the *abc* conjecture, one of the biggest open problems in number theory, has been accepted for publication.

Acceptance of the work in *Publications of the Research Institute for Mathematical Sciences* is the latest development in a long and acrimonious controversy over the mathematician’s proof. The journal, of which Mochizuki is chief editor, is published by Japan’s Research Institute for Mathematical Sciences (RIMS) at Kyoto University, where he works.

Two other RIMS mathematicians, Masaki Kashiwara and Akio Tamagawa, announced the publication at a press conference in Kyoto on 3 April. The paper “will have a big impact”, said Kashiwara.

Mochizuki, who has denied requests for interviews over the years, did not appear at the press conference, and did not make himself available to reporters.

Eight years ago, Mochizuki posted four massive papers online, claiming to have solved the *abc* conjecture. The work baffled mathematicians, who spent years trying to understand it. In 2018, two respected mathematicians said they were confident they had found a flaw in Mochizuki’s proof – something many saw as a death blow to his claims.

The latest announcement seems unlikely to move many researchers over to Mochizuki’s camp. “I think it is safe to say that there has not been much change in the community opinion since 2018,” says Kiran Kedlaya, a number theorist at the University of California, San Diego, who was among the experts who put considerable effort into trying to verify Mochizuki’s claimed proof. Another mathematician, Edward Frenkel at the University of California, Berkeley, says: “I will withhold my judgement on the publication of this work until it actually happens, as new information might emerge.”

The *abc* conjecture expresses a profound link between the addition and multiplication of integer numbers. Any integer can be factored into prime numbers, its ‘divisors’: for example,  $60 = 5 \times 3 \times 2 \times 2$ . The conjecture roughly states that if a lot of small primes

divide two numbers, *a* and *b*, then only a few, large ones divide their sum, *c*.

A confirmed proof could change number theory by, for example, providing an innovative approach to proving Fermat’s last theorem, the legendary problem formulated by Pierre de Fermat in 1637 and solved only in 1994.

Many mathematicians found Mochizuki’s proof to be written in an impenetrable, idiosyncratic style, built entirely on unfamiliar mathematical concepts.

Mochizuki has declined all invitations to travel abroad to lecture about his work. Although, at the time, some of his close collaborators said they found the proof to be correct, experts around the world struggled to slog through it, let alone verify it. Conferences were held on the subject, and participants reported partial progress, but said it would probably take many years to come to a conclusion.

In 2018, two German mathematicians – Peter Scholze at the University of Bonn and Jakob Stix at Goethe University, Frankfurt – privately circulated a rebuttal of the *abc* proof, zeroing in on one crucial passage that they said was faulty. In September that year, the pair went public with their finding: an article in the maths and physics magazine *Quanta* quoted them describing a “serious, unfixable gap”, as Stix put it.

In comments posted on his website at the time, Mochizuki brushed the criticisms aside, hinting that the two authors had simply failed to understand his work. But several experts told *Nature* that much of the mathematics community considered the matter settled at that point. The official acceptance of the papers seems unlikely to change this.

At the press conference, Tamagawa said the solution itself had not changed in response to Scholze and Stix’s criticism. Some comments about it will be published in the manuscript, but there will be no fundamental alteration, said Tamagawa.

In the world of mathematics, a journal’s seal of approval is often not the end of the peer-review process. An important result truly becomes an accepted theorem only after the community has reached a consensus that it is correct, and achieving this can take years after a paper’s official publication.

Additional reporting by David Cyranoski.