**////Title: Exploring the Ethics and Environmental Impact of Chemistry**

**////Standfirst:**

From its early days, the field of chemistry has been exploring nature at the molecular level. As such, chemistry is also used to explore natural resources and possible ways of exploiting them. As Earth’s environment is now rapidly deteriorating, chemists need to adapt their practices with the aim of contributing to its protection. Dr Surjani Wonorahardjo, Dr Suharti Suharti and Dr I Wayan Dasna, three researchers in Indonesia, have recently conducted a study exploring the ethical and environmental issues associated with current chemistry practices, in the hope to inspire reflection and positive change in the field.

**////Main text:**

Over the past few centuries, human activity has caused the destruction of countless natural environments. To repair the damage done and enable the survival of both humans and other species living on Earth, individuals and organisations worldwide need to implement profound changes, reflecting on the ethical implications of their actions and practices.

This is also true for chemists, who have historically revealed many compounds and materials in nature, which could then be exploited as natural resources. Chemistry is the scientific field that investigates the atoms and molecules that matter is made up of, their properties, and the reactions between them.

Chemistry research has played a crucial role in shaping human activities over time. For instance, it led to the introduction of new industrial processes. It also identified the ways in which atoms and molecules behave and change, to create new molecules and materials that now underpin the functioning of our modern technologies.

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Many of the environmental issues affecting our planet are closely linked to chemistry and Earth’s chemical make-up, including pollution in the atmosphere and the oceans, climate change, the accumulation of plastic, and the depletion of natural resources. As the destruction of our planet is closely related to the use of damaging pollutants or the extraction of precious substances, chemists could also play a key role in re-shaping human activities and promoting the preservation of natural environments.

With this in mind, Drs Surjani Wonorahardjo, Suharti Suharti and I Wayan Dasna, three researchers at Universitas Negeri Malang and State University of Malang, in Indonesia, have recently carried out a study focusing on the ethical and environmental aspects of chemistry. In addition to outlining environmental issues that can be closely linked to chemistry, the researchers reflected on ethical changes in the field that could encourage greater sustainability and contribute to the protection of natural environments.

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Chemists play a crucial role in the identification and creation of materials that can be used to build, power, and optimise modern technologies.

This role is heavily emphasised by Dr Wonorahardjo and her colleagues, who suggest that just like chemistry played a role in understanding fossil fuels, it is now underpinning the development of renewable energy technologies and their implementation. The operation of solar cells and hydropower technology, for instance, heavily relies on chemical processes.

Chemical processes also play a key role in the extraction of raw materials and the processing of plastic and synthetic textile fibres. In the future, the work of chemists could thus also play a role in identifying alternative extraction and production strategies that do not harm the environment.

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Dr Wonorahardjo and her team also examined the crucial role that analytical chemistry plays in both damaging and preserving the natural environment. This is the area of chemistry that focuses on the development and validation of chemical methods.

For instance, analytical chemists can help to develop harmful pesticides. Alternatively, they could instead focus on developing bio-pesticides that do not harm the environment, or methods that assess the health of an ecosystem. In addition, they could aid the creation of catalytic converters and other technologies that reduce air pollution.

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The recent paper by Dr Wonorahardjo and her colleagues also explores the concept of self-organisation – the process through which an unbalanced natural environment comes to a turning point and gradually balances itself. Many self-organisation processes observed in nature are linked to chemistry.

In addition, the researchers reflect on the potential of data science – the field focused on the collection, processing and analysis of large amounts of data – in relation to chemistry. More specifically, they point out that analytical chemistry and other areas of chemistry can generate large amounts of environmental data, which could then be analysed to gain more insight about the environment and inform the development of effective strategies to protect it.

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In its final section, the researchers’ paper highlights the need to integrate ethical considerations into the academic curricula of both existing and new chemistry courses. In fact, training chemistry professionals who are mindful of the effects that different processes and practices have on the environment could promote significant positive changes in the field.

Dr Wonorahardjo and her team specifically emphasise the importance of introducing chemistry students to environmental ethics, teaching them the importance of making science more human, ethical, and sustainable. A term that has recently been circulating among educators is ‘green chemistry’, which can define attempts to make chemistry education and practices fully environmentally friendly.

To contribute to the battle against climate change and to protect the natural environment, chemists can now refer to the Global Chemist Code of Conduct. This is an important document that contains a series of rules and suggestions that chemists can follow to ensure that their work is ethical and does not damage organisms, processes, and ecosystems on Earth.

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All scientific activity could help to preserve natural environments and build a more sustainable future, if carried out wisely, responsibly, and ethically. Educating new generations about the challenges we are facing today and teaching them to operate ethically should thus be a key priority for all science educators worldwide.

The recent paper by Dr Wonorahardjo and her colleagues effectively summarises some of the ways in which chemists can help to protect the environment, while also highlighting the necessity to include ethics-related topics in academic curricula. In the future, it could inspire further studies and discussions about the ethics of chemistry and its impact on the environment.

This could lead to the development of new regulations, educational guidelines, and academic courses that prioritise the protection of the planet and all of its inhabitants.

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This SciPod is a summary of the paper ‘From Chemistry Back to Nature, an Ethical Perception of Chemists’, from *The 4th International Conference on Mathematics and Science Education (ICoMSE).* <https://doi.org/10.1063/5.0043206>

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