

An interview with Paul Crutzen, awarded Nobel Prize in Chemistry in 1995

Interview by Pietro Tundo

1. From your bibliography it is quite evident that you approached the meteorological research by pure serendipity. Which aspect of stratospheric chemistry first engendered your curiosity in the field?

Crutzen - I started out as a civil engineer, it had nothing to do with chemistry, but I got a little tired of engineering and wanted to get into a pure science. I was offered a job as a computer programmer at Stockholm University, that was around 1961 when the computing facilities were not so advanced as now. We had to do machine coding so it was quite an art to be a programmer at that time. I was appointed in the Institute of Meteorology where I helped other people to write and carry out programming and one opportunity arose with a scientist from the United States. He was at the University of Stockholm for two years and he wanted to do a study on atmospheric ozone and he got me involved as a programmer and while I was programming I got more and more interested in the subject. It was initially believed that you could explain the ozone distribution in the atmosphere using only 4 reactions, which were first proposed in 1930. One of the things I basically came to the conclusion of, is that many more reactions are needed to explain the concentration of ozone in the stratosphere and troposphere and that is through the catalytic activity of nitrogen oxides.

2. In your Nobel lecture you stated that if Joe Farman and his colleagues from the British Antarctic Survey had not persevered in making their measurements in the harsh Antarctic environment, the discovery of the ozone hole may have been substantially delayed and there may have been far less urgency to reach international agreement on the phasing out of CFC production. You also suggested that gradually, over a period of a century or so, stratospheric ozone should recover. Fifteen years on from that statement the stratospheric ozone seems to be recovering. What contribution do you think should be made to increase the rate of recovery?

It's a very slow process, it takes about 50 to a 100 years before most of the CFC gases are removed from the atmosphere, there is no way you can speed it up. It's dependent on the input of UV radiation from the sun and we can not change that so we have to live with it, it takes a lot of time before the CFC gases are removed from the atmosphere, there is no way to get around it. **If the radiation from the Sun increases, the depletion or recovery is increased or not?** No, the UV radiation which removes the CFCs does not affect ozone by its self. The CFCs when exposed to UV break down to elements - chlorine and bromine- and these break down products are water soluble. They have to then reach the troposphere where there is enough water vapour to form rain clouds and when it rains, the break down products are removed from the atmosphere.

3. The climate change issue seems to be the subject of endless debate. If you had to convince someone of the influence of man's activity on climate change, which arguments and facts will you most likely employ to do so?

Well we know that the temperatures are increasing around the world, 0.7 °C since pre-industrial times. We know also that glaciers are melting, especially in the Alpine region, where we're seeing a serious decline in the surface area of glaciers. This is also seen in South America in the Andies and also in the Himalayas. **So we see that there is much data that shows that the temperature**

of the Earth is gradually increasing. Here many people are worried that such an increase will destroy Venice within the next century with rising sea levels. Yes a rise in sea levels has been noted, it's not occurring very quickly but levels are rising, another indication that the climate is changing. They are micro indicators.

4. What do you believe should be done in order to radically limit man-made greenhouse gases?

As long as we depend on fossil fuels as an energy source with CO₂ coming from them, we have this problem, so as soon as possible, we have to make sure that we switch to other energy sources. For instance bio-fuels are a possibility but they have to be managed correctly. **So the main intervention is to limit the use of fossil fuels and to improve the utilisation of energy from natural resources.** Yes and also we should stop deforestation. **The question is also another one, how best to utilise the very large energy sources in oceans and the seas, this is a technological challenge because the sea has a lot of energy, tidal flows, currents, waves, how to utilise them, do you think it will be easy to harness such energy.** I don't think it will be easy.

5. In a few days, you will receive the *Laurea Honoris Causa* in Environmental Sciences at the Università Ca'Foscari Venezia for your outstanding contribution to the science of the atmosphere. What is in your opinion the perception of the young generations toward the environmental related issues and how should we better encourage them to undergo a career in science ?

I'm working here in an institute where we have many students, not only from Germany but from around the world so there is an interest among students to get involved in environmental research. This is a field that has definitely grown, so I don't think it will be very difficult to get new young scientists. To get young people involved in science is necessary because there are so many problems to be solved and also any time you make a discovery it gives you a sense of duty, there is so much still to discover, jumping back to the fossil fuels issue, the whole energy area is a place where a lot of research is still needed to create energy sources that do not depend on fossil fuels. We need young people and there are plenty of jobs and plenty of problems to work on. **This may be important also in order to connect the science of the old western continents to the emerging ones, such as China and India in Asia, so to establish networks between the young generations of all the countries, to initiate dialogue in how to go ahead (in how to progress environmental research?).** How is the situation in Italy, are young people interested in environmental science? **There are many young people here that are very interested in the field, but it depends also on the political situation. What we do know is that the young generation, the latest students, they are more willing to progress, they don't automatically follow the suggestions of the older generations, so I have a hope, a dream.**

6. Do you think Green Chemistry can help improve the opinion that people have of chemistry and of chemists?

I hope so, again we come back to the issue of fossil fuels and products utilising them as feedstocks. We have to produce goods and the energy we need to produce and run them, this has to be supplied by other means than fossil fuels. So I think there is an important task for green chemistry for the future of our planet. **Green chemistry is also to think about chemistry from a fundamental point of view, not only application but to think of how to carry out reactions in a greener way, to eliminate waste, to utilise all the atoms, to write new reaction pathways etc.**

7. Finally, this is a question we have posed to all the Nobel laureates we have interviewed. Do you think ethical issues should be addressed by science? Do you believe they should be included in a student's curriculum?

Yes I definitely think so, we can use science in bad ways, like the development of nuclear weapons, which is probably one of the worst ways in which science has been misused and I think ethical issues should be included in the curriculum of students.