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Levels of water and soil natural pollutions in Italy

Annibale Mottana[1] · Sergio Carrà[2] · Carlo Doglioni[3]

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This issue of *Rendiconti Lincei Scienze Fisiche e Naturali* communicates the best papers presented to a conference held in Rome, at the Accademia Nazionale dei Lincei, on March 20, 2015. This year, the 15th World Water Day lectures were dedicated to the level of natural pollution of the Italian environment, in order to separate what is geogenic in origin and what rather relates to anthropogenic input, and in preparation of the next year's day entirely dedicated to man-induced pollution. The geology of Italy is such as to present numerous areas where high levels of pollution affect soils because of natural causes (mainly related to their near or distant volcanic origin). Consequently, pollution affects the waters too, both those running on and those moving in the near surface aquifers; or—to say it more precisely—certain Italian waters may exceed the safety limits set by the European Community for agricultural and industrial uses. The cases where drinking waters exceed such safety limits are much rarer, thanks to vigilant attention of the authorities taking care of environment and safety (ASL) and yet a few of them occur in localised spots throughout the entire country.

Opening the conference, Professor *Michele Caputo*, the Chairman of the Lincei Academy Commission on Environment and Natural Disasters, pointed out that the popular press stresses on the great number and new types of disasters that were unknown in the past, giving the perception that risk is constantly increasing all over the Italian territory. One could confute this trend by stating that this situation is a natural one, i.e., it originates from evolution induced by causes that are beyond the human possibility to cope with. However, this truth does not justify the authorities who do not take care of the three constraints: preview, prevent and provide. Indeed, climate changes so rapidly as to make it is practically impossible to estimate the related risk in advance and the previewing action becomes a political issue: what the authorities can actually do is tied up, rather, with their willingness at spending people money properly. Professor Caputo gave clear indication on this issue referring to agriculture, hydrocarbon extraction and landslides. He also pointed out that a great deal of problems derives from atmospheric pollution, which is a global problem rather than a national one.

Altogether, the Conference presented 27 oral papers either solicited or offered and eleven posters. We selected ten of the oral presentations and three posters as representative of the best research on the subject to be included in this issue of *Rendiconti*. Five of them are invited lectures (out of eight given) and the others were either short oral communications or posters converted into regular papers.

Stating the well-known and still valid quote of Paracelsus "the dose makes the poison", Dr. *Carlo Cremisini* of ENEA—the National Agency for New Technologies, Energy and Sustainable Economic Development—gave the introductory lecture (Cremisini and Armiento 2016). He showed that chemical elements naturally distribute in soils and waters either in concentrations that are too low (deficiency) or too high (toxicity), leaving just a short interval where they can be absorbed proficiently by the living bodies. Among the elements that

✉ Annibale Mottana
annibale.mottana@uniroma3.it

[1] Dipartimento di Scienze, Università Roma Tre, Largo S. Leonardo Murialdo 1, 00146 Rome, Italy

[2] Dipartimento di Chimica, Materiali e Ingegneria Chimica "Giulio Natta", Politecnico di Milano, Via Mancinelli 7, 20131 Milano, Italy

[3] Dipartimento di Scienze della Terra, Sapienza Università di Roma, Piazzale Aldo Moro 5, 00185 Rome, Italy

are potentially toxic, some cover rather large geographical areas. Their elevated concentrations are due to natural causes, thus creating a true geochemical risk. Indeed, those elements interfere negatively with the biosphere. Thus, it is important to study, realise and map whether such chemicals in excess are natural (i.e., geogenic) or anthropogenic in origin and to determine the geochemical factors that influence their mobility in order to remediate effectively the ensuing environmental problems. Among the examples given, he insisted particularly on As, but also on F and U, as being all factors of geochemical risk over large areas of Latium. Finally, he drew the listener attention on the discrepancies existing between the European Union (EU) and Italian legislations on the matter as a cause of environmental misbehaviour.

Professor *Pasquale Mario Nuccio* of the University of Palermo and associate researcher of the INGV—Istituto Nazionale di Geofisica e Vulcanologia—spoke about some of the main contamination processes linked to magmatism (Nuccio 2016). He described the hydrothermal activities of black and white smokers at the bottom of oceans and gave other deeper examples out of the Mediterranean area, including volcanic ash deposition, soil saturation with carbon dioxide and emission of radioactive radon. He pointed out their toxic effects on people, with emphasis for their implications and relevance in planning the use and the management of both soils and waters of a given area.

Professor *Paolo Censi* and his research group at Palermo University documented how weathering of evaporites influences the chemistry of continental runoff, making surface waters poorly exploitable for civil uses (Censi et al. 2016). They described the results gathered on an area of south-central Sicily, where this phenomenon is at its worst because of the occurrence of abandoned landfills of sulphur, salt and kainite dismissed mines. Weathering induces V, Cr and Fe desorption from the sediments and the particulates under reducing conditions, while releasing Rb and Cs that originally were contained in halite. In the Stincone-Salito stream system, the chemical reactions lead to a sharp growth of As content, believed to be due to As release from Fe-bearing solids. Increasing salinity and euxinic water conditions favour a growth of residence time of toxic elements in those river waters.

Dr. *Giovanna Armiento,* acting as spokesperson for a large group of researcher of ENEA, reported a comprehensive overview regarding U concentrations in natural waters (Armiento et al. 2016). She listed more than 3000 data on waters all over Italy, in addition to new data for Latium Region, well known for its relatively high U concentrations in rocks. Actually, U in bedrock is not the main factor determining its amount in running waters and groundwater. Redox conditions as well as bicarbonates and silicates control solution equilibria influence strongly the U content in waters. At present, and considering the provisional EU guideline value of 30 μg/L for U, the situation is not critical, but it may become so in the near future, when new, lower limits will be introduced.

The case of Latium is so peculiar as to motivate studies by several research units, each one working under different viewpoint.

Dr. *Stefano Fazi*, acting for a group from IRSA-CNR and INAIL located in Rome, related on a case study carried out all over Latium, the area known for the largest As contamination of its waters (Fazi et al. 2016). In an aquatic environment, As is often attributable to geogenic processes occurring within aquifers. The authors dealt also with the main As removal technologies and the potential application of combined chemical and biological strategies aiming at increasing the efficiency of biological As (III) oxidation to As (V) by means of cell-detoxifying mechanisms or metabolic processes. They also addressed the role of microorganisms in the mobility of As in natural systems as well as the distribution of As-resistant bacteria that are potentially suitable for As removal.

Dr. *Elisabetta Preziosi* and co-workers evaluated the Latium regional groundwater body scale by the preselection method, choosing the 95th percentile of the preselected datasets for various groundwater bodies (Preziosi et al. 2016). The natural background levels differ at the groundwater full body scale reflecting the complexity of the geological asset. At a smaller scale, the background variations can be dramatic even at short distance, and this will constrain the site scale assessment. By contrast, the time variation of the considered parameters appears to be modest, thus the overall chemical status assessment considering the background levels would result "good". Actually, there are excesses of arsenic and fluoride, which explain some recent erroneous evaluations as being anthropogenic.

Dr. *Pasquale Avino* and his group of co-authors examined the water provision for a large city as Rome is (Avino et al. 2016). They analysed 20 water samples drawn from municipal potable facilities for 38 elements, and could confirm that all elements in all the aqueducts deducted from springs are well below the limits posed by the regulations on water for human consumption, being close to uncontaminated natural water. Besides, the monitored waters resulted safe from a toxicological point of view, and adequate from nutritional aims.

Another case study attracting many research units is the Po river delta, which collects streams running from both the Alps and the Apennines and waters from the irrigated fields of the fertile lower Padana Plain. A group from the University of Ferrara consisting of several researchers presented three papers, one of which in collaboration with a researcher in the Helmholtz Center for Environmental

Research at Halle, Germany. All presentations dealt with various properties of the flowing waters sampled in the Po delta.

The first paper, given orally (Marchina et al. 2016), presented new geochemical analyses made to evaluate the extent of salinization due to mixing with seawater and to monitor the flux of nutrients conveyed by the river toward the coastal environment. The oxygen/hydrogen water isotopes represent a snapshot of the current climatic conditions: their study aims at contributing to the future construction of a hydro-archive, updated to evaluate on-going climatic changes. Moreover, this future archive should also contain nitrogen isotopes data, which trace the impact of human activities, to understand possible on-going pollutions. The suggestion was at implementing geochemical research on the Po river delta because it is an extremely fragile ecosystem where biogeochemical variations are most relevant.

The second paper (Corazzari et al. 2016), given originally as a poster (indeed, it was the poster evaluated to have the best outlay) dealt with the C and N elemental and isotopic compositions of the suspended load of the Po river waters sampled in distinct hydrological periods. Main results are: (1) one can to discriminate natural (i.e., geogenic) and anthropogenic components; (2) one can trace geochemical fluxes transferred from the Po river to the Adriatic Sea; (3) using total C properly speciated in its organic and inorganic components, one can determine the provenance of the particles from either the Alps or the Apennines; (4) using N speciation, one may get insights on the pollution affecting the river, thus forecast possible Adriatic eutrophication episodes.

Finally, a third contribution, again given originally as a poster and converted into a regular paper (Mastrocicco et al. 2016), deals with geogenic trace element contamination. It reports the temporal and spatial variation of major ions and trace elements in a shallow unconfined aquifer belonging to a complex marsh saline environment reclaimed in modern age and intensively cultivated, by using depth profiles to evaluate groundwater and sediment matrix interactions. Dominant factor determining the trace element spatial variability is the sediment–water interaction, while their temporal variation is a combination of the organic matter content and of the water table oscillations, which in turn drive the groundwater redox status. The general conclusion is that, despite the possible anthropogenic input from fertilisers, the combined use of high-resolution sediment profiles, seasonal groundwater samplings and end-member analyses represents a promising procedure to distinguish between anthropogenic metal contamination and geogenic contribution in a reclaimed deltaic environment.

This issue of *Rendiconti Lincei* includes a number of papers that do not focus onto a single subject of general interest. Rather, they contribute to the general problem by dealing with rarely used methodological approaches or by describing the water situation in poorly studied, secluded areas (*e.g.*, Grecía Salentina, a few villages at the very centre of the heel of the boot representative of the Italian peninsula).

Dr. *Maria Lionetto* and her co-workers from the University of Salento at Lecce (Lionetto et al. 2016) showed how eco-toxicological methods represent an emerging approach to biomonitoring the quality of waters and soils by using "sentinel organisms" as biomarkers during the reclaimed wastewaters reuse for irrigation.

Dr. *Antonella De Donno* and her co-workers (Bagordo et al. 2016), again from the Salento University, in their poster applied the Driver-Pressure-State-Impact-Response (DPSIR) framework to the case study of Grecía Salentina, with the aim at identifying environmental and human factors influencing the quality of groundwater and at proposing strategies for its preservation. By taking into account eleven indicators for the Driving forces, five for Pressures, twenty-one for States, two for Impacts and three for Responses, they could suggest hypotheses regarding the causes of poor water quality and, correspondingly, propose management strategies to correct the negative aspects of the overall state of health of the aquifer. Another paper (Infusino et al. 2016) has also its focus on a Southern Italy forest.

Dr. *Maura Manganelli* of ISS—Istituto Superiore di Sanità, Roma (Manganelli 2016)—presented the audience with a careful description of primary producers (microalgae and cyanobacteria) that synthesise harmful bio-toxins, or that are dangerous to environment because of the large amount of biomass they produce during bloom. A significant increase in the number of toxic blooms, toxic species and toxins is well known worldwide, but there is still no consensus on the causes. They described the state of the art on marine and freshwater species in Italy and highlighted on what one would rate as major research problem.

When writing this editorial six months after the conference, we ask ourselves what will turn out from next year's meeting, which will address specifically the anthropogenic chemical pollution detected in soils and waters. Are the current methods adequate to discriminate between geogenic and anthropogenic pollutions to suggest workable technologies for mitigation? If so, which chemical elements should have priority, as being the most dangerous to the national welfare? Should certain elements be classified as second rank in importance, although harmful, in order not to interfere with decontamination and with industrial or agricultural processes that bring benefits to the entire country? The recent case of the Taranto steel plant, where decontamination of a small area compelled to un-employment many steel workers, should warn the law-

enforcers to get the best information and push the research to the maximum. Should researchers freely supply their data, despite being incomplete, so that a correct scientific information will transform contamination into a political issue, up to the regulations enforced, but widely disregarded, by the European Community? Which control should the research community have on an environmental situation that persistently documents strong anomalies, and suggests that certain disasters are within the possibility of regulation by humans informed on time? Next year's meeting will answer many of these queries, but only because the path has been set by this year's one.

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