Severe particulate pollution from the deposition practices of the primary materials of a cement plant

This work in under publication in Environ. Sci. Pollut. Res., available as "online first" at http://link.springer.com/article/10.1007/s11356-014-2969-6

K. Kourtidis [1], S. Rapsomanikis[1], A. K. Georgoulias [1], C. Zerefos[2], E. Pavlidou[3]

[1]Department of Environmental Engineering, School of Engineering, Democritus University of Thrace, 12 Vas. Sofias str., 67100 Xanthi, Greece, [2]Research Center for Atmospheric Physics and Climatology, Academy of Athens, 24 Omirou str., 10672 Athens, Greece,
[3]Section of Solid State Physics, Physics Dept, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

Annual cement production has increased from around 1.7 Gtn in 2000 to around 3.3 Gtn in 2010 (Kelly and van Oss 2010; USGS 2011) and 3.7 Gtn in 2012. This increase has been primarily driven by India, China and other developing countries. China is currently producing nearly half of the world's cement, followed by India and the U.S., while cement production is expected to continue to increase in the future (Sun et al. 2010 and references therein).

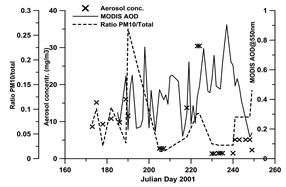
Objectives

Despite the very large amounts used globally and the large increasing trends, there is no literature available on the impact of cement plant primary materials storage and deposition practices on ambient particulate matter. **The objective of this work is to reduce this gap and study the influence of the outdoor deposition of primary materials used by the cement industry on ambient particulate levels.** To that end, we conducted a study involving both in-situ sampling and remote sensing of a cement plant that stored outdoors during the 1990s and early 2000s.

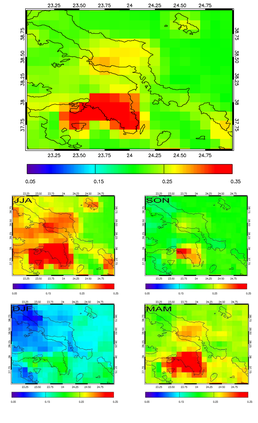
Study area

The study was conducted in the region around the town of Halkida, Greece, where the HERACLES-III cement plant (Lafarge Group) is operating (Fig), producing 2.5 Mtn of cement/yr. The production method is dry and uses pre-heating and pre-calcination. The plant operates two quarries: the limestone quarry (850,000 m2), and the clay quarry (300,000 m2) (Fig.). During the period of the sampling, the plant stored large quantities of primary materials (clinker, pet coke, fly ash) outdoors.

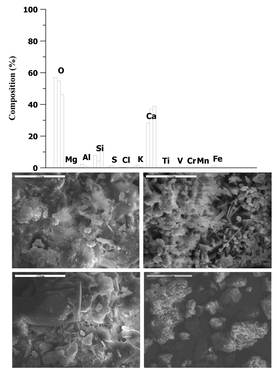
Results



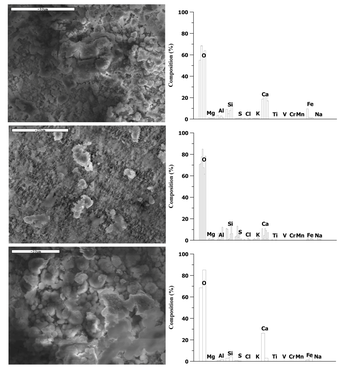
TSP determined by the samples, MODIS overpass AOD550 satellite data and ratio of PM10 to TSP (PM10/TSP). PM10 concentrations are in most cases much higher - up to two orders of magnitude higher in fact - than the WHO PM10 guidelines of 20 ug/m3 annual mean and 50 ug/m3 24-hr mean as well as the EC Council Directive 40 ug/m3 annual standard.



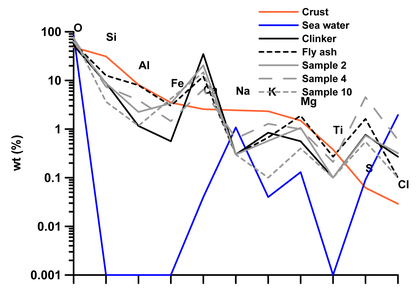
Spatial extend of aerosol pollution (from MODIS AOD data).



Top: Clinker elemental analysis (wt%) by SEM/EDS. Different bars in each element represent analyses of different positions of the sample. Middle and bottom: SEM micrographs of the sample. The white bar is 20 um across, except for the bottom right where it is 200 um.



SEM micrographs of the sample (at left) and SEM/EDS elemental analysis (wt%) results (at right) of filters (from top to bottom) No. 2 (24 June 2001), No. 4 (1 July 2001), and No. 10 (15 September 2001). Different bars in each element represent analyses of different positions of the sample by SEM/EDS. White bars at the SEM micrographs are 50, 20, and 20 um, respectively. Samples are morphologically quite similar to clinker; additionally, their composition is very similar to the clinker one.



Comparison of crustal, clinker, fly ash, and sample elemental composition. Crustal composition after Rudnick and Gao, 2003; sea water composition after Turekian, 1968; clinker, fly ash and sample composition by SEM/EDS (this work). Ambient particulate samples are elementally very similar to clinker, confirming its dominant influence on ambient particulate levels.

Conclusions

Considerable pollution from particulates may result from the practice of some cement plants of depositing their clinker outdoors. Observed PM10 levels were orders of magnitude above the EC Council Directive 40 ug/m3 annual standard and the WHO PM10 guidelines of 20 ug/m3 annual mean and 50 ug/m3 24-hr mean.

In many parts of the world, current environmental legislation and its enforcement may be similar to conditions reported here. Furthermore, neither the primary material for the manufacture of OPC nor the manufacturing process have changed during this period. In fact, the mix in use today for the manufacture of OPC is the same as the one designed in the mid-19th century. Additionally, the cement plant studied belongs to a company that is a world leader in building materials and operates plants in 75 countries. **Given the global increase in construction, especially in South-east Asia, and the associated need for cement, the results presented here may be of timely relevance. It appears that the outdoor deposition of primary materials for cement has the potential to be a dominant source of particulate pollution in the vicinity of cement plants.**

References

Kelly TD, van Oss HG (2010) Cement statistics. U.S. Geological Syrvey (USGS); Rudnick RL, Gao S (2003) The Composition of the Continental Crust. In: Holland HD, Turekian KK (eds) Treatise on Geochemistry, Elsevier-Pergamon, Oxford, pp 1-64; Sun H, Jain R, Nguyen K, Zuckerman J (2010) Clean Technol. Environ. Policy 12:503-516; Turekian KK (1968) Oceans. Prentice-Hall

Acknowledgements

This research has been financed by EPAN II and PEP under the national action "Bilateral, multilateral and regional R&T cooperations" (AEROVIS Sino-Greek project).