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Climate change impact on river assimilative capacity: a case study application of water related climatic indicators

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Abstract

In this investigation, we use climatic, water-related indicators to evaluate the impact of climate change on the assimilative capacity of the Asopos River, Central Greece. Indicators were developed and organised under the SWICCA climate service (http://swicca.eu), which aims to develop and showcase a Water Management Information Service for the Copernicus Climate Change Service based, among others, on real case studies and end-users. River flow indicators are the core data for evaluating the assimilative capacity of the Asopos River under different scenarios regarding average flow conditions. Assimilative capacity was evaluated for 6 heavy metals, namely Cr, Cd, Cu, Pb, Ni and Zn. Socioeconomic indicators (GDP and Land Use) were also utilized to incorporate changes of economic activities in the assessment. Climate impact indicators are free of the need for laborious processing. They cannot cover all aspects of local analysis needs but, combined with local information, they are key-data for integrated climate change impact investigations. Results from 226 scenarios of circulation, regional and impact models combinations as well as industrial activity evolution, indicate for the majority of the scenarios, a small impact on the river's assimilative capacity, associated with climate change, while industrial activity evolution could have a significant effect.

Keywords: Climate change, Asopos, Copernicus, climatic indicators, surface waters

1. Introduction

The Asopos River basin is located in central Greece, at the River Basin District of Eastern Sterea Ellada, covering an area of approximately 720 km^2. Its water bodies receive significant pressures both in terms of quantity and quality, mainly attributed to water abstraction for irrigation and to the significant industrial activity in the area, respectively. The latter reflects approximately 20% of the total national industrial production. The River's capacity for assimilating treated industrial effluents, which supports a fragile balance between environmental status preservation and sustainable economy, is exposed to climatic pressures and there is a need for estimating probable climate change impacts on this capacity in order to ensure environmental sustainability along with economic growth of local industry.

2. Methods

The Emission Limit Values (ELVs) for industries was selected as the indicator of the River's assimilation capacity, because it incorporates effluent emissions, environmental regulations (through Environmental Quality Standards, EQS) and river hydrology. For the calculation of ELVs, the wPOLIS web application (http://switchon.emvis.gr/polis) was used. Based on a simple water quality model, it determines the maximum concentration of pollutant in the industries effluent so that the concentration in the river remains below the EQS limit (Common Ministerial Decision Num 20488/31-5-2010).

The climatic indicator used is the hydrological input for ELV calculation, the discharge of Asopos River. Monthly averaged values were provided from the SWICCA climate service (Service for Water Indicators in Climate Change Adaptation, http://swicca.eu) for a reference (1971-2000) and two future periods (2011-2040 and 2041-2070 hereafter referred to as 2020s and 2050s, respectively), for 11 combinations of Global, Regional climatic models and Representative Concentration Pathways scenarios (RCP2.6, 4.5 and 8.5). Flows from three impact models, E-HYPE (http://hypeweb.smhi.se/model-water/), VIC (https://vic.readthedocs.io/en/master/) and Lisflood (https://bit.ly/2PTyF2e) were used. The low summer flows were used for ELV calculation.

A literature review about industrial activity in Asopos River Basin (e.g. NTUA 2009; LIFE CHARM Del.4.6), which is related directly to the river (e.g. effluent receiver), led to the number of industries that are discharging their effluent in Asopos River (24). ELVs were determined for 6 heavy metals namely Chromium (Cr), Cadmium (Cd), Copper (Cu), Lead (Pb), Nickel (Ni) and Zinc (Zn).

Available SWICCA scenarios of Gross Domestic Product indicators (GDP), along with Land Use indicators were utilized to investigate the future development of the local industrial activity. A qualitative approach was followed leading to three scenarios (20% decrease, no change, 20% increase).

The combination of the scenarios described in the above paragraphs yields 226 scenarios in total, examined for each pollutant.

3. Results and Discussion

Climate change impact evaluation was based on the relative change of ELVs between the future periods and the reference period, rather than the absolute values. In that way, differences between the methodology used and the methodology for the official, regulatory determination of ELVs as well as possible errors in the river discharge values used, are not reflected on the assessment. ELVs increase indicates an increase of the River's assimilative capacity.

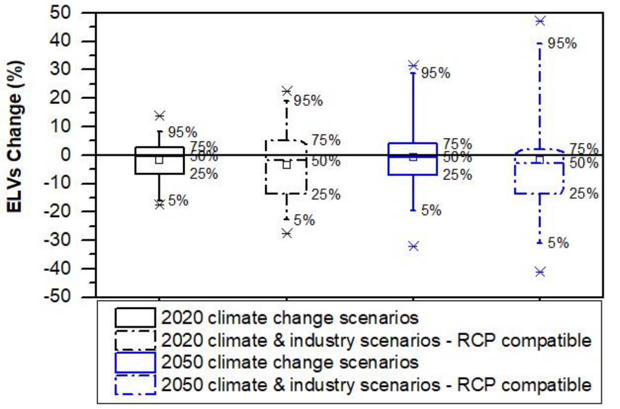

Figure 1. Relative change of ELVs for all the metals examined, for climate change and industry scenarios and for the time periods examined.

As presented in Fig.1, the range of ELVs change in 2020s period is small for the groups "climate change scenarios" incorporating the assumption of no change in industrial activity, while the mean and median is almost 0%. The same is valid for 2050s period with a slight larger range. If we consider changes in the range of ±10% as not significant, then for no change in industrial activity, climate change impact is marginal on the ELVs change, especially for the 2020s period where 87% of scenarios examined (42% increase + 45% decrease) gave changes less than ±10%.

If industry scenarios are taken into account, then results present a larger spread and the mean and median values show a slight decrease in the ELVs values. 33% of scenarios present a decrease more than 10% and 15% present an increase more than 10%, for the period 2020s, while similar results are computed for 2050s.

The effect of impact models (hydrological models) which produced river discharges, declines for the 2050s period, where the results are similar for all three models. For the 2020s (Fig.2), E-HYPE results lead to some scenarios with decreased ELVs values, smaller than -10%. Output from Lisflood and VIC leads to a larger percentage of scenarios with ELVs increase.

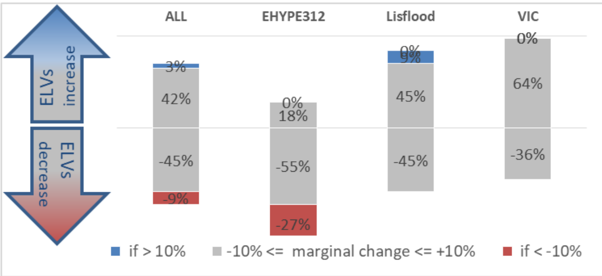

Figure 2. Relative change of Chromium ELVs for climate change and industry scenarios and time periods examined, based on flows output from different impact models.

The incorporation of industry scenarios has a larger effect on ELVs than climate change does. However, it is not significant in terms of median values but it rather increases the spread of possible ELV values, as shown in Fig.1 and more detailed, in Fig.3 where changes of Chromium ELVs are presented.

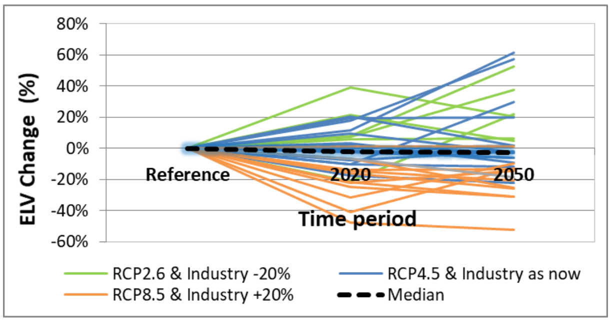

Figure 3. Relative change of Chromium ELVs for climate change and industry scenarios and time periods examined.

In general, the conclusions drawn for chromium are also valid for the rest of the metals examined. Some differences between the results for different metals indicate that for some pollutants the regulatory compliance risks, under climate change, are higher and a more detailed evaluation would be probably needed.

Acknowledgments

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