Methodology for spatial analysis of pesticide residue monitoring data in surface water

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Directive 2009/128/CE of European Parliament and Council on Sustainable Use of Pesticides introduced a community action framework to protect the EU Environment and requested Member States to implement policies and actions to reduce the risk of pesticide use. In Italy, this Directive was adopted with D.Lgs. n.150 14/08/2012, followed by DGR n. X/3233 adopted on 06/03/2015 in the Lombardy Region: "*Approvazione delle linee guida per l'applicazione in Lombardia del piano di azione nazionale (PAN) per l'uso sostenibile dei prodotti fitosanitari*"

General Objectives of the D.Lgs 150 - National Level

- Reduce pesticide risks and impacts on human health, environment and biodiversity.
- Promote application of integrated pest management, organic agriculture and other alternative approaches.
- Protect pesticide operators and farmers.
- Protect the consumers.
- Protect aquatic environment and drinking water.
- Preserve biodiversity and ecosystems.

Regional objectives to the realization of National D.Lgs. n. 150 also aim to follow common objectives of Directive 2009/128/CE, of 2000/60/CE (Water Framework Directive), of 92/43/CEE (Directive on the conservation of natural habitats and plant life and wild animals) and 2009/147/CE (Directive on conservation of wild birds).

2009/128/CE

D.Lgs 150 14/08/2012

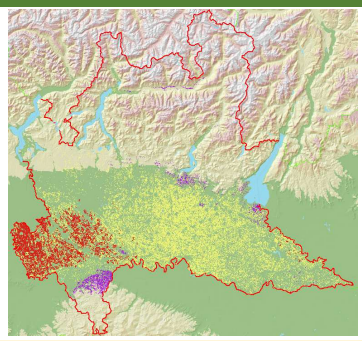
DGR X/3233

Specific Objectives of DGR n. X/3233 – Regional Level

- Training and provision for users, distributors and consultants
- Implement a certified control system, check and service of sprayers
- Support specific protection actions in high priority environmental areas and in protecting the aquatic environment
- Develop and upgrade the surface water and ground water monitoring planning
- Promote low pesticide-input management including non-chemical methods
- Protection of Nature 2000 areas
- Increment the number of stations to collect agro-meteorological data
- Reduce pesticide product use in urban areas, streets and railroads
- Enhance the dissemination of agro-meteorological dispatches with correct treatment strategies
- Improve the knowledge of real pesticide load (in terms of kg or Liters) into the environment and reduce illegal pesticide products

Regional Characterization

The food farming system of the Region Lombardy is the most relevant at national level and one of the most important in the European context.
The agro-business in Lombardy Region exceeds the 12.2 Billions of euros (15.6% of the National production); it involves almost 70000 productive structures, with more than 245000 workers, over a territory of 0.58% of the EU-27 surface.
The Regional Gross Domestic product represents 2.6% of the entire European Union.
Considering the structure of the food farming system and the productive vocation of the Lombardy Region, the adoption of the D.Lgs. n. 150 focusses in particular on: maize, due to its coverage in the Lombardy landscape and to the strategic relevance in the zootechnical system. Rice, due to the peculiarity of its way of cultivation and on its particular environment. Vines, due to the high number of pesticide treatments and to the economic importance at Regional level.



FOCUS on pesticide risk for surface water: approach

2,4-D	Diuron	Molinate
2,6-Dichlorobenzamide	Fluroxypyr	Oxadiazon
Aclonifen	Glyphosate	Pendimethalin
Alphamethrin	Imidacloprid	Pretilachlor
Aminomethylphosphonic acid	Linuron	Propanil
Azimsulfuron	Malathion	Quinoxyfen
Bensulfuron-methyl	MCPA	Terbuthylazine
Bentazone	Metalaxyl	Terbuthylazine-desethyl
Chlorpyrifos	Metamitron	Terbutryn
Chlorpyrifos-methyl	Metribuzin	Thymol
Dicamba		

Materials
- The pesticide maximum concentration detected in SW was considered as the max Measured Environmental Concentration – MEC_{max}
- The pesticide annual average concentration detected in SW was considered as the average MEC - $MEC_{average}$
- A collection of ecotoxicological data have been retrieved for all the monitored pesticides from the Active Substance assessment reports
- For each pesticide, PNEC has been derived from the ecotoxicological endpoint of the most sensitive specie divided by a safety factor

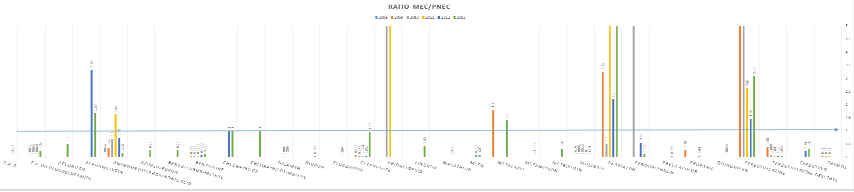
Dataset

Limits of the approach
- Surface water monitoring network is not specifically designed for pesticides, but for general purposes related to water quality
- The sampling frequency is scheduled to occur quarterly a year, it does not correspond to the best practice to proper detect pesticides in surface water
- The monitoring punctual data of pesticides in SW is a snap-shot of a situation that could over/under estimate an environmental pesticide pollution

Methods

First screening of the potential qualitative pesticide risk for surface water was performed by comparing the MEC with the Environmental Quality Standard (annual average or maximum concentration) – EQS (Italian Regulation Limit - DM 260/2010) **MEC/EQS**

To assess the pesticide risk to the aquatic ecosystem, the detected MEC_{max} were compared with the Predicted No Effect Concentrations. **MEC/PNEC** value lower than 1 were considered situations to be addressed.



Results

Glyphosate: it represents the active substance with the greatest number of MEC/PNEC exceedance: high distribution also within urban areas (agricultural and extra-agricultural uses)
Terbuthylazine: the third active substance in terms of MEC/PNEC exceedance even if the residue concentrations show a descending trend.
Oxadiazon: the number of MEC/PNEC exceedance related to this substance shows an increasing trend, mostly connected to rice crop.

Conclusions

The complexity of the processes related to the pesticide use in the Lombardy Region needs to be accurately addressed.

Some of the pesticides detected in surface water are included constantly and more frequently into monitoring programs than others: often the monitored active substances do not correspond with the most hazardous substances for aquatic environment. Detailed, specific and fact-finding assessments have to be a first essential action in the future monitoring plans together with a constant update in the monitoring programs

Specific recommendations were drawn :
Terbuthylazine and Oxadiazon were detected once or more than once in the selected monitoring period with a ratio MEC_{max}/PNEC greater than 1.
Some insecticides can cause an alert to the environment even when their monitored concentration values are below the EQS of 0.1 µg/L.
Metolachlor, not authorized anymore has to be substituted in the monitoring programs with S-metolachlor.
Glyphosate, even with acceptable MEC/PNEC ratios, results to be highly diffused over the Lombardy Region surface water network both in agricultural areas and in urban areas: mitigation is necessary

References

DIRECTIVE 2009/128/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides.

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D.G.R. 6 marzo 2015 - n. X/3233. Giunta della Regione Lombardia. Regional adoption of the guidelines of Decreto legislativo 14 agosto 2012, n. 150 for the sustainable use of pesticides.

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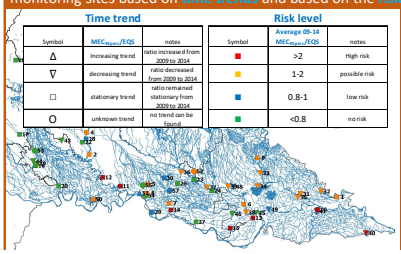
Decreto 8 novembre 2010, n. 260. Ministero dell'Ambiente e della Tutela del Territorio e del Mare. Regolamento recante i criteri tecnici per la classificazione dello stato dei corpi idrici superficiali.

DIRECTIVE 2013/39/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy

Proposed Mitigation measures

		Mitigation	2016	2017	2018	Note
Terbuthylazine	pre-emergence	Substance use reduction	max allowed 80% of UAL on maize	max allowed 70% of UAL on maize	max allowed 50% of UAL on maize	The same percentages might be reached with the adoption of localized herbicide applications during sowing activities
	post-emergence	Drift mitigation		TBA treatments have to be performed with a drift reduction of 30%		
Glyphosate	in agricultural areas	Substance use reduction	max allowed 80% of UAL	max allowed 70% of UAL	max allowed 50% of UAL	Excluded from these limitations are the farmers who joined the official programs of conservation agriculture
		Drift mitigation		Glyphosate treatments have to be performed with a drift reduction of 30%		
Oxadiazon	on rice crop (*)	Substance use reduction	max allowed 80% of UAL on rice	max allowed 70% of UAL on rice	max allowed 50% of UAL on rice	(*) rice crop with paddy fields managed with row seeding and alternate irrigation
		Drift mitigation		Oxadiazon treatments have to be performed with a drift reduction of 30%		

ratio $MEC_{95percentile}$/EQS, and $MEC_{95percentile}$/PNEC. This approach consists in the characterization of the results of the monitoring sites based on time trends and based on the risk level classification as shown in the picture below.

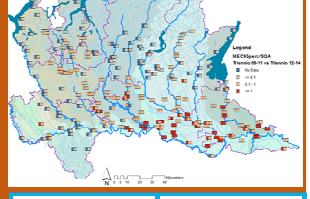


From the combination of the two classifications, it is possible to create a chart identifying the action necessary to mitigate the risk in the area characterized by increasing trend and in particular in the upstream areas.

Time Trend	Risk level	Risk mitigation, action to be performed
Decreasing	Possible risk	keep the situation monitored
Decreasing	High risk	Specific assessment
Stationary	Low risk	keep the situation monitored
Stationary	Possible risk	necessary/highly suggested
Stationary	High risk	necessary/highly suggested
Increasing	Possible risk	necessary/highly suggested
Increasing	High risk	necessary/highly suggested
Unknown	Possible risk	necessary/highly suggested
Unknown	High risk	necessary/highly suggested

Follow up

To selectively identify areas where mitigation measures are needed, instead of a general application on all the Regional territory, a further step has been developed by a working group with collaborators coming from different Regional Authorities.
Starting from Regional EPA database of surface water pesticide monitoring concentrations (2009-2014), the proposed methodology (MEC/PNEC & MEC/EQS ratios) was applied to the $MEC_{95percentile}$/year and to the $MEC_{average}$/year, in addition to the MEC_{max}/year.
The monitoring sampling points were georeferenced with a GIS, and mapped to visualize the measured concentration compared with PNEC and EQS.
To identify a concentration trend on time series, a comparison between the first three-year period (2009-2011) and the second one (2012-2014) was performed (aside).
A second approach was developed considering just the



Poster Summary