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PREDICTION OF POTENTIALLY HAZARDOUS PRTR CHEMICALS IN LAKE BIWA-YODO RIVER BASIN OF JAPAN BY USING ONE BOX MULTIMEDIA MODEL

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EXTENDED ABSTRACT

PREDICTION OF POTENTIALLY HAZARDOUS PRTR CHEMICALS IN LAKE BIWA-YODO RIVER BASIN OF JAPAN BY USING ONE BOX MULTIMEDIA MODEL

1. Introduction

Our environment is becoming the sink for the chemical pollutants released by the increasing amount of industries, thus constantly becoming unsuitable for living organisms. When the chemical pollution in the environment reaches to a threshold level, these chemicals will begin to damage the environment and the health of humans, plants and animals. Well-known situations such as Minamata disease caused by methyl-mercury poisoning in Kumamoto, Japan (Harada, 1995) or Itai-Itai disease caused by cadmium poisoning in Toyoma Prefecture in Japan (Inaba *et al.*, 2005) reveal that we become aware of these adverse effects by these chemicals after the damage become apparent. Environmental monitoring for these chemical pollutants are conducted to obtain a better understanding of the environmental pollution condition. Since environmental monitoring requires trained and well qualified chemical analysts, cutting edge technologies, and more funding, it is a difficult and not very practical task when there is no proper method to identify which kind of chemical pollutants to focus on.

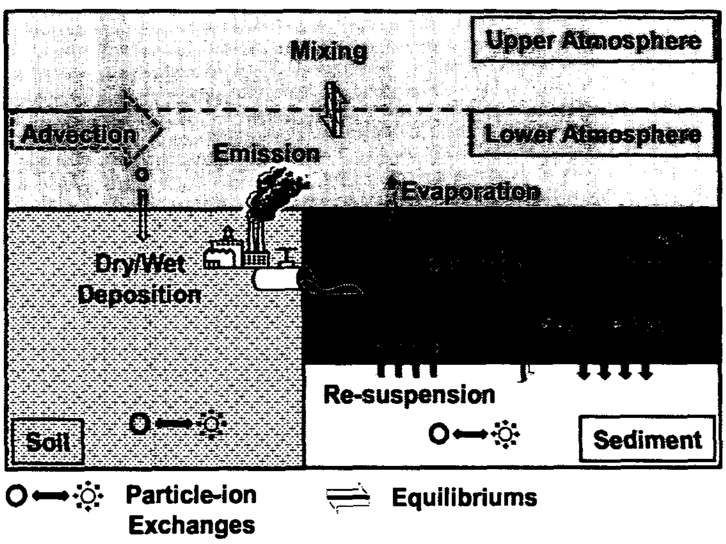

Fig. 1 Diagrammatic explanation of the chemical phenomena of pollutants considered in the OMM model.

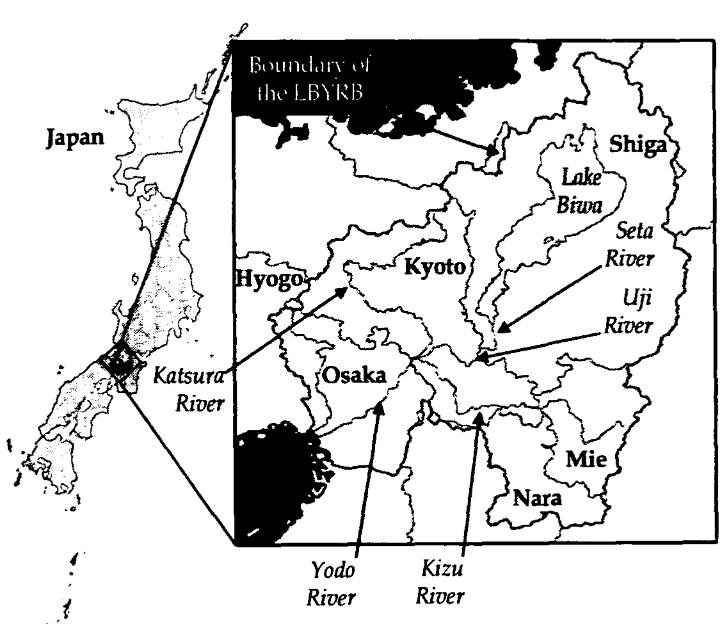

Fig. 2 Boundaries and major aquatic systems in LBYRB

In order to address this drawback, the necessity of a system which can identify and predict the potentially hazardous chemical pollutants and their geographical occurrences in the environment was recognized.

Considering nine chemical transport mechanisms; Emission, Degradation, Dry/wet deposition, Sedimentation, Re-suspension, Advection, Atmospheric mixing, and Particle and ionic exchanges in the environmental media of atmosphere, soil, water, and in sediments, One-Box Multimedia Model **(OBMM)** was developed and used for computational calculation of the concentration of various pollutants in different environmental media of the study site **(Figure. 1)** (Ariyadasa *et al*, 2015). Lake Biwa-Yodo River Basin **(LBYRB)** is one of the densely populated and industrialized areas in Kansai region of Japan with diverse land use patterns. It is the main natural water sources for nearly 11 million population in the Kinki region (Sudo, 2002). Therefore LBYRB was selected as the study site for this study.

2. Literature Review

United States Environmental Protection Authority (USEPA) reports using atmospheric models such as: Community Multi-scale Air Quality Model (CMAQ), Air Quality Model Evaluation International Initiative (AQMEII), ect. to evaluate pollutant circulation (USEPA, 2013). In their review on hydrological modeling of basin-scale climate change and urban development impacts, Praskievicz and Chang summarizes the various hydrological models such as Parallel Climate Model (PCM), and Precipitation-Runoff Modeling System (PRMS), to evaluate different hydrological scenario (Praskievicz and Chang, 2009). But many of these modeling studies have been performed only for certain environmental media.

In this study we combined all four environmental media into a computer model. Nine chemical parameters of were considered in the model calculations and the study span was 11 years. Due to these characteristics, this research study would strongly stand out from the researches carried out in the similar field of study.

3. Objective of the study

Thus identification and prediction of potentially risk possessing non-metallic PRTR chemicals in LBYRB, by using OBMM was set as the main objective of this study.

4. Methods

4.1 Data sources and data collection

Since the PRTR in Japan provides a well-organized chemical emission data base, it was considered to use these data as initial input data and to use computational modeling to develop this system to predict the behavior and fate of the chemical pollutants (JMOE, 2007). PRTR data mainly consist of two categories; Registered PRTR Data *(The registered PRTR data provide the emissions and quantities of chemicals transferred per year by compound, area, and industry. The locations of the emission sources were provided as addresses in the PRTR system*) and Non-Registered PRTR Data (*The non-registered PRTR data include the diffuse or non-point-source emissions estimated for businesses that are smaller in size or product volume, non-listed industries, households, and mobile sources. These data are delimited by emissions to the atmosphere, water, landfills and soil. Emissions to landfills and soil were negligible and thus were not considered in the calculation of non-registered emissions in this study. As these data were provided by region, estimation was required to calculate the total emissions in the LBYRB. The population ratio of the LBYRB to the Kinki region was assumed to be representative to the ratio of emissions between LBYRB and to that of Kinki region*).

(23)

Two hundred non-metallic PRTR chemical pollutants were initially selected for this study and their annual emission data was calculated using PRTR data. For the PRTR registered emissions, the emission sources inside the study site were identified using GIS address matching software. Non-registered PRTR emissions were estimated proportionately to the population in six prefectures of kinki region to that of the study area. Emission data was calculated for random three years; 1997, 2002 and 2008 selected on temporal span.

4.2 OBMM Simulations

Emission data was fed into the OBMM model and calculations were carried out. Output data of concentration levels in four different environmental media for those 3 model simulations were then analyzed for their trends in concentration and concentration level.

4.3 Development of screening scenarios

Calculated concentrations (or results) from the OBMM were analyzed for trends in concentration in each of the environmental media from 1997 to 2008. Chemicals were screened using the following criteria to identify the risk possessing PRTR chemicals as shown in the **Fig. 3**.

- For possessing non-declining concentration trends over the time span of the study.
- For possessing the highest calculated concentration in each environmental media (upper 10% of the 200 chemicals, listed descendingly on their averaged calculated concentrations).
- For the occurrences in all four environmental media.

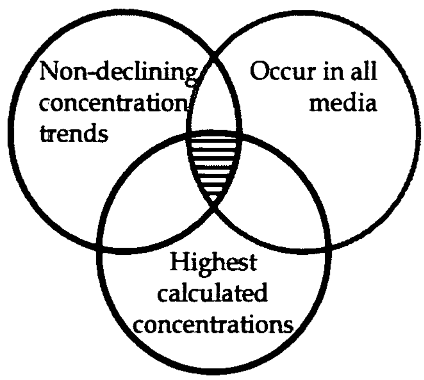

Fig. 3 Scenario used for screening the risk possessing chemicals.

5. Findings And Discussion

General trend of concentration levels of the 200 non-metallic PRTR chemicals were declining with the time from 1997 to 2008 but several pollutants showed deviated trends from the declining trend. **Figure 4** shows the relation and the number of chemicals showing the non-declining trend and the higher 10 % of the calculated concentrations for each media. Out of the 35 chemical pollutants screened at this level, seven chemical pollutants given in the **Table 1** were occurring in all environmental media, thus full filling the all screening criteria.

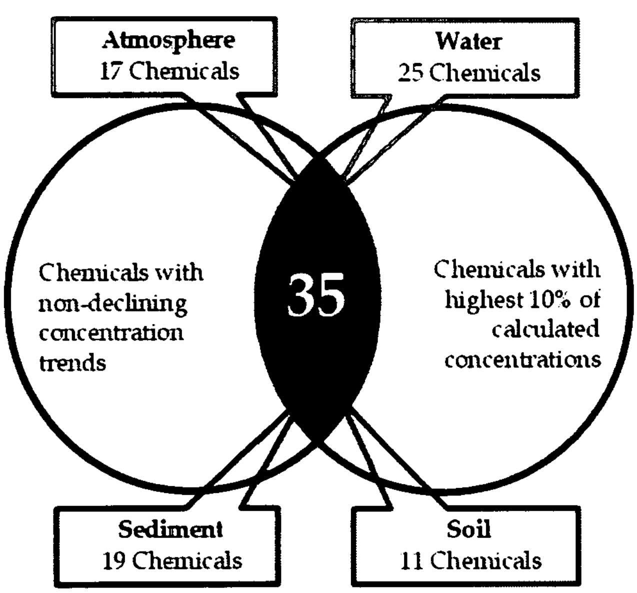

Fig. 4 Number of chemicals possessing both non-declining concentration trends and the highest 10% of calculated concentrations.

6. Conclusion

Table 1 Potentially hazardous chemical pollutants occurring in all four environmental media.

PRTR No	Chemical Name (IUPAC name)*	Cas No
65	Glyoxal (ethanedial)*	107-22-2
90	Shimazine (6-chloro-N-N-diethyl-1,3,5-triazine-2,4-diamine)*	122-34-9
146	Dithianon (5,10-dihydro-5,10-dioxonaphtho[2,3-b]-1,4-dithiine-2,3-dicarbonitrile)*	3347-22-6
179	Dioxins	
238	N-nitrosodiphenylamine (N,N-di(phenyl)nitrous amide)*	86-30-6
239	p-Nitrophenol (4-Nitrophenol)*	100-02-7
300	1,2,4-Benzenetricarboxylic 1,2-anhydride (1,3-dioxo-2-benzofuran-5-carboxylic acid)*	552-30-7

In this study seven chemical pollutants were identified as potentially risk possessing PRTR pollutants occur in LBYRB by using OBMM simulations and the screening criteria developed. These predictions can help to focus the environmental monitoring process on those potentially hazardous chemical pollutants, so that proactive mitigation measures can be taken to prevent further damages to the environment.

References

- Ariyadasa B.H.A.K.T., Kondo A., Inoue Y., 2015, "Temporal screening for hazardous PRTR chemicals in the Lake Biwa-Yodo River Basin of Japan using a one-box multimedia model", Journal of Environmental Science and Pollution Research, Springer. Vol. 22, no. 4, pp. 2757-2764.
- Harada M., 1995, "Minamata disease: methyl mercury poisoning in Japan caused by environmental pollution", Critical Reviews in Toxicology, Vol. 25, no. 1, pp. 1-24.
- Inaba T., Kobayashi E., Suwazono Y., Uetani M., Oishi M., Nakagawa H., and Nogawa K., 2005, "Estimation of cumulative cadmium intake causing Itai-Itai disease", Toxicology Letters, Vol. 159, pp. 192- 201.
- Sudo M., Kunimasu T., and Okubo T., 2002 " Concentration and loading of pesticide residue in Lake Biwa basin (Japan), Water Resources, Vol. 36, pp. 315-329.
- International programs of USEPA, 2013. Transboundary Air Pollution. Referred from the United States Environmental Protection Agency website (http://www.epa.gov/international/air/trans_air.htm).
- Praskievicz S. and Chang H., 2009. "A review of hydrological modeling of basin-scale climate change and urban development impacts". Progress in Physical Geography, Vol. 33, no. 5, pp. 650-671.
- Ministry of Environment, Japan, 2007. PRTR Information Plaza. Ministry of Environment website referred from (http://www.env.go.jp/en/chemi/prtr/prtr.html)

The 25th Symposium on Environmental Chemistry, Tharaka Ariyadasa, Oral presentation (Niigata; 2016)

Assessment of potentially hazardous PRTR chemicals in Lake Biwa-Yodo River basin of Japan, by using One-box multimedia model

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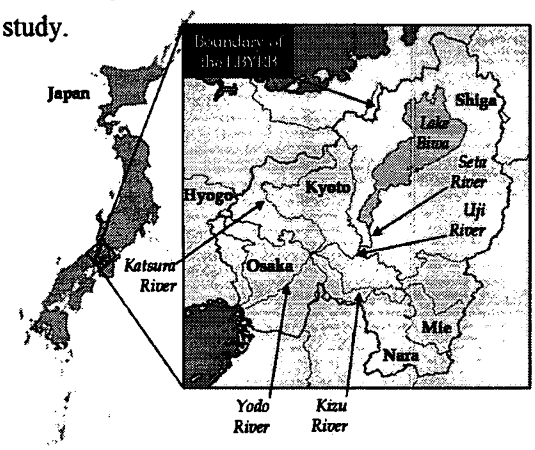
Environmental monitoring are conducted to obtain a better understanding of the environmental pollution condition as our environment is becoming the sink for the chemical pollutants released by the increasing amount of industries and our life styles. It is a difficult and not very practical task when there is no proper method to identify which kind of chemical pollutants to focus on. In order to address this drawback, the necessity of a system which can identify and predict the potentially hazardous chemical pollutants and their geographical occurrences in the environment was recognized. Therefore Assessment of potentially risk possessing non-metallic PRTR chemicals in LBYRB, by using OBMM was set as the main objective of this study.



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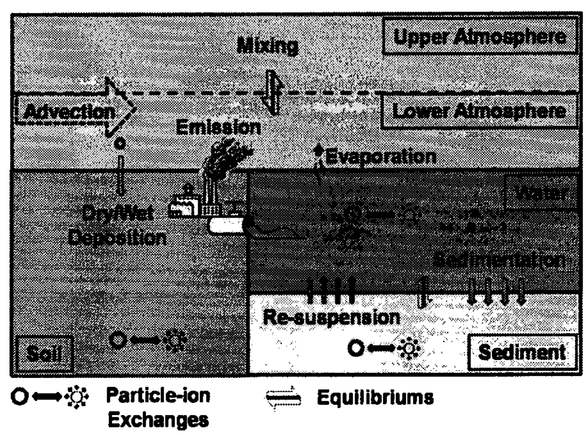
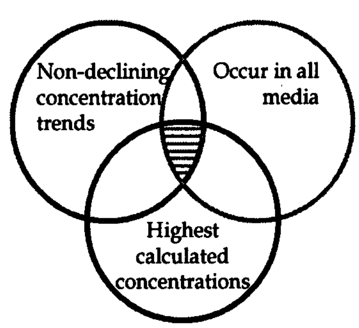


Fig. 2 Diagrammatic explanation of the chemical phenomena of pollutants considered in the OMM model.

[Methods]

Lake Biwa-Yodo River Basin was selected as the study site for this research because of its diverse land use patterns as a densely populated and industrialized areas in Kansai region of Japan [1]. One-box multimedia model was developed considering nine chemical transport mechanisms; Emission, Degradation, Dry/wet deposition, Sedimentation, Re-suspension, Advection, Atmospheric mixing, and Particle and ionic exchanges in the environmental media of atmosphere, soil, water, and in sediments, to mathematically interpret the behavior and fate of the chemicals in the environmental media **(Fig. 2)** [2 & 3]. Annual emission amounts required as initial input data were estimated using registered and non-registered PRTR data from the



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1) Sudo M., Kunimasu T., and Okubo T. 2002. Water Resources 36: 315-329.
2) Ariyadasa B.H.A.K.T., Kondo A., Inoue Y. 2015. Journal of Environmental Science and Pollution Research, Springer 22(4):2757-2764.
3) Praskievicz S. and Chang H. 2009. Progress in Physical Geography 33(5):650-671.
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