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The inventory of sources, environmental releases and risk assessment for perfluorooctane sulfonate in China

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ABSTRACT

With about 100 t/y of the production volume, perfluorootane sulfonates (PFOS) are mainly used for metal plating, aqueous fire-fighting foams (AFFFs) and sulfluramidin China, and the use amount is about 30–40 t/y, 25–35 t/y and 4–8 t/y respectively. Based on the inventory of PFOS production and uses with geographic distribution educed from statistics, environmental risk assessment of PFOS was taken by using EUSES model, as well as its environmental releases were estimated both in local and regional levels in China. While the environmental release from manufacture is significant in Central China region, metal plating was identified as the major PFOS release source in regional level. The East China region shows the most strong emission strength of PFOS. Though the predicted environmental concentrations (PECs) were not exceed current relevant predicted no effect concentrations (PNECs) of the risk characterization for PFOS, higher PECs was estimated around major PFOS release sources showing undesirable environmental risk at local level.
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1. Introduction

With the unique properties of high surface activity, chemical stability and acid resistance, perfluorooctane sulfonate (PFOS) and related substances have been used in a wide range of products and industrial processes, such as fire-fighting foams, carpets, leather/apparel, textiles/upholstery, coatings and coating additives, industrial and domestic/household cleaning products, pesticides and insecticides, photolithography, semi-conductor, hydraulic fluids and metal plating (UNEP, 2006). Due to the properties of persistence, bioaccumulation and toxicity, Perfluorooctane sulfonate and related compounds were listed into the Annex B by Stockholm Convention on Persistent Organic Pollutants (POPs) in May 2009 (UNEP, 2009) to restrict or eliminate their production and uses. Currently, because of lacking of cost-effective alternative technologies in certain applications, PFOS and related substances are still manufactured and used in China. The production volume of PFOS is about 100 tons per year, which is mainly used in metal plating as chrome mist inhibitor, in fire-fighting foams as surfactant, in sulfluramid as a raw material and in other industries.

Recently a decade, PFOS and related substances have been monitored in water, sediment, soil mediums from some areas as the upper reaches and delta of Yangtze River (Pan and You, 2010; Yamashita et al., 2007), Pearl River Delta (Jin et al., 2010; Yamashita et al., 2007), the Haihe River (Sun et al., 2011) and coastal areas of Bohai Sea (Lu et al., 2011a) and so on. Simultaneously, concentrations of PFOS from general population in some areas of China were about the same levels as that in America and Japan (Li et al., 2009; Yamashita et al., 2008). The trend of health risk assessment for PFOS is found gradually upward in China (Jiang et al., 2006; Jin et al., 2004; Li et al., 2009). Nevertheless, separated monitoring data of PFOS at scattered local areas could not reveal a systematic environmental risk status of PFOS in large territory of China due to lacking of detailed information on sources, releases and associate risk assessment of PFOS.

In this paper, an inventory of the production and use of PFOS was developed based on surveys. The distribution of PFOS sources and environmental releases were estimated based on the inventory, relevant statistics and specific natural and environmental management situation of China, and an overall environmental risk assessment of PFOS was taken by using state-modified EUSES model.

2. Production and uses of PFOS

2.1. Production of PFOS

Since 3M Company, the largest manufacturer of PFOS, announced to phase out production of PFOS in 2000 (3M, 2000), global production volume of PFOS had declined significantly (Sweetman et al., 2009). However, the number of PFOS producers increased from 2002 to 2006 in China (Huang et al., 2010), which

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reached 13–15 at the peak. Also the trend of production volumes of PFOS was an upward in China as the almost only production country. In 2002, production volume of PFOS was about 30 t in China, and then it increased to 246.88 t in 2006. Since then, under the impact of the international policy to restrict or eliminate PFOS production, production volume of PFOS was declined to about 100 t/y in 2008 (Huang et al., 2010). Fig. 1 shows that the trend for production volumes of PFOS from 2002 to 2008 in China.

According to surveys for PFOS manufacture enterprises, Yangtze River chemical plant first began to carry out research and development for PFOS manufacture in late 1970s. Due to increasing market demand of PFOS and related substances, the PFOS production volume continued to expand in China. About 10 producers were located in Hubei Province, including the largest company in China, whose annual output was about 60 t. Production volume of PFOS in Hubei Province accounted for 80%–90% of that in China. The other 3 PFOS producers were located in Fujian province, where occupied lower share of production in China.

2.2. Uses of PFOS

PFOS and related substances had ever been extensively used in textiles, carpets, leathers about five years ago, while now it is not be used in these applications due to the international restriction of such applications. The use amount of PFOS is very limited in semi-conductors and aviation (Mei, 2008). Currently, PFOS and related substances are mainly used in metal plating, aqueous fire-fighting foams (AFFFs) synthesis and sulfluramid formulation.

2.3. PFOS use in metal plating (chromium)

In metal plating process, PFOS are mainly used assurfactant/wetting agent and mist suppressants in hard and decorative chromeplating, which can reduce the emission of chromium and improve the work environment in this sector. The amount of PFOS used in China was been estimated as 30–40 t/y from metal plating industry survey in 2008. Such a using level maintained stable in the last years. More than thousands of metal plating processing enterprises are densely located in Jiangsu, Zhejiang, Shanghai, Liaoning and Guangzhou Provinces where steel and mechanical treatment industry are relatively developed in China. Based on the statistics of production volumes of clad sheet in different provinces of China (CISA, 2010), the distributions of the PFOS using amount in metal plating across China are derived as Fig. 2, reflecting large

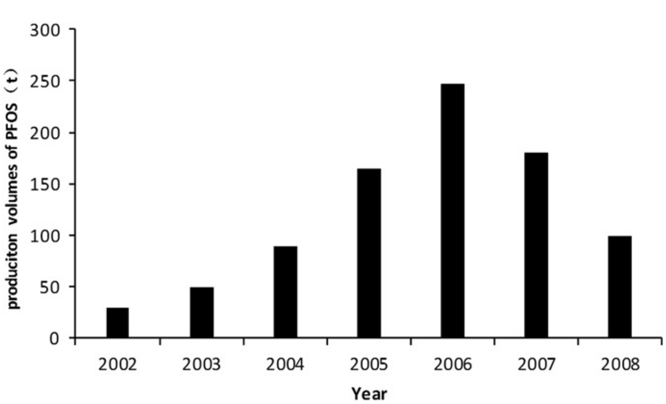

Fig. 1. Production volumes of PFOS from 2002 to 2008 in China.

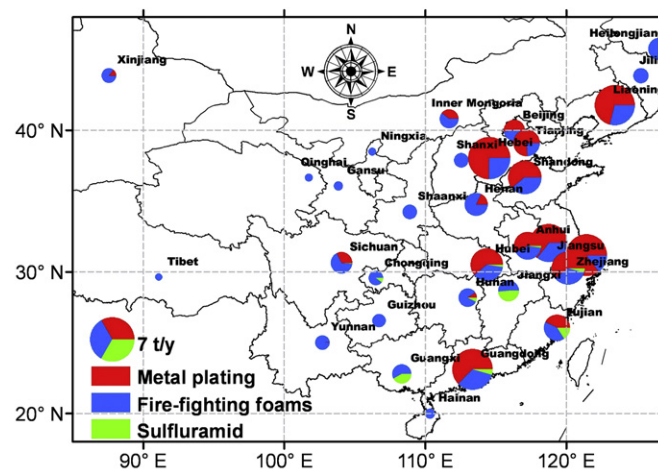

Fig. 2. The distribution of PFOS use amounts used in metal plating, fire-fighting foams and sulfluramid applications in 31 provinces of China.

using amount in metal plating are concentrated around coastal areas of China.

2.4. PFOS use in fire-fighting foams

PFOS has been widely used to synthesize aqueous fire-fighting foams (AFFFs) for its high efficiency, low-cost, easy-to-use (Moody and Field, 2000). Fluorinated surfactants mainly contribute to the performance of AFFFs to prevent re-ignition of fuel and oils. A survey conducted by Fire Department of Ministry of Public Security of China indicated that, 28% of fire-fighting foams producers were using PFOS as a raw material to synthesize AFFFs. The percentage of AFFFs in all types foams were keeping increasing from 24.8% to 32.4% (Yu et al., 2010). Assuming that the percentage of PFOS among AFFFs product is 0.5%–1.5% (Moody and Field, 2000), the use of PFOS in this application was 25–35 t per year as fluorinated surfactants. AFFFs containing PFOS are especially applied for fire protection in petrochemical, fire brigade and military facilities and similar areas. By contrast, it is a minimal amount used in residential and commercial buildings fire services. The use tonnage of AFFFs containing PFOS accounted for 24.6 percent of production volumes per year, averaged from 2001 to 2008 (Yu et al., 2010). In 2008, the amount of PFOS released to environment was 6.15–8.61 t/y due to extensive use of AFFFs in the course of fire. The remaining AFFFs usually were stored in the fixed fire-extinguishing systems or mobile fire-fighting equipment (fire foam engines) of different provinces in China. According to the sizes of the projected provincial fire services equipment (FDMPS, 2009), a distribution of using amount of PFOS in fire-fighting foams, including use for fire services and stock, is estimated as shown in Fig. 2. It shows that higher use amounts of PFOS were in Guangdong, Jiangsu, Heilongjiang Provinces for fire-fighting foams use and stock, where having intensive petroleum and chemical industry.

2.5. PFOS use in sulfluramid

Sulfluramid, an important intermediate as fluorinated surfactants to formulate organic fluorine pesticide, has been mainly used to control termites and other crawling insects due to its insecticidal effect in cities (Harrad and Goosey, 2011). It also becomes an alternative for mirex which was prohibited by Stockholm Convention as a POPs (Gao et al., 2001). Actually, sulfluramid is a salt formulated using PFOS as raw materials. In China, there was only one sulfluramid manufacturer, which is located in Jiangsu Province. About 4–8 t/y of PFOS was used to formulate in sulfluramid manufacture according to the survey in 2008. According to the statistic data of mirex use in termite control areas of China, the distribution of the fraction of PFOS using volume in sulfluramid use is derived as shown in Fig. 2. In Jiangxi and Guangxi Provinces, the fractions of PFOS using amount in sulfluramid use are higher than those in other provinces.

As shown in Fig. 2, using products and industrial processes of PFOS, are mainly distributed in the South-East half part of China, where just represents the dominant area of China with intensive industrialization and advanced social-economic development.

3. Releases of PFOS to the environment

3.1. Releases of PFOS during manufacture, industrial use and formulation in local scale

ECF (electro-chemical fluorination) process, developed by 3M company and widely used by the global producers, is also applied by PFOS manufacturers in China. PFOS emission scenario was no significant difference between Chinese and oversea manufacturing processes. Applying the emission factors of PFOS developed from international PFOS producers (Sweetman et al., 2009), the estimated environmental releases of PFOS from the China's largest PFOS manufacturer located in Hubei Province, were 315.6 kg/y and 525.0 kg/y to local air and water compartment, representing the maximal releases during PFOS manufacture at local level.

In the process of metal plating, PFOS are used to lower the surface tension of metal planting solutions to prevent the formation of mists including potentially harmful components from the baths. Generally, the concentration of chrome mist inhibitor containing PFOS is about 20–40 mg/l in the treatment bath (Mei, 2008). Applying the Emission Scenario Document on Metal Finishing (OECD, 2004), for a metal plant of relative large-scale in China which normally contains about 20 metal plating workshops, the release of PFOS from such a plant to local water compartment is bout 2.88 kg/y which was shown in Table 1. Because of the semi-volatile property of PFOS, the release of PFOS to air is too low to be considered.

In the fire-fighting foams industry, taking account of the use amount of PFOS in a AFFFs manufacturer about 1.80 t/y PFOS in average,the releases of PFOS to local air and water compartment were estimated to be 1.76 kg/y and 35.3 kg/y respectively (Table 1),by applying emission factors of chemical used in synthesis from Technical Guidance Documents (TGD) (EC, 2003).

As for sulfluramid formulation, the releases of PFOS to local air, water and soil compartment were estimated to be 15.0 kg/y, 120 kg/y and 0.60 kg/y respectively by applying relevant emission factors on pesticides in personal/domestic places from TGD (EC, 2003).

3.2. Releases of PFOS to the environment in regional scale

The processes of PFOS manufacture, industrial use in metal plating, AFFFs synthesis and sulfluramid formulation as well as uses of AFFFs at a fire and sulfluramid for termites control, would release a large amount of PFOS into environment. Lots of enterprises for manufacturing and using PFOS are scattered in different provinces. Besides, AFFFs and sulfluramid are dispersed used in different regions. Considering the geographical distribution of the production and use of PFOS, the South-East half part of China, as the dominant PFOS production and use area, can be divided into six regions, i.e., Northeast China, Central-north China, Central China, Southwest China, East China and South China. Regional releases of PFOS from manufacture and its uses in metal plating, fire-fighting foams and sulfluramid application into water, sediment, soil are estimated according to relevant emission scenarios, which are shown in Table 2. Major manufacturers for PFOS are located in Hubei Province in Central China region, which lead to release of PFOS into this regional environment to be estimated between 0.715 and 2.177 t/y. Industrial use of PFOS as chrome mist inhibitor was estimated as the largest source of PFOS pollution in almost each region, with a maximum regional release at 15.69 t/y in East China. Followed by the AFFFs industry, the main releases of PFOS is due to AFFFs used in the fire-fighting scenes, causing regional pollution in water and soil. As for sulfluramid, lower contribution is considered to the regional releases. Among six regions, as the most intensive industrial economy developed areas of China, East China showed the highest regional emission strength of PFOS which was about 24.45 g/km^2 y, and then followed by Central-north China, South China, Central China, Northeast China and southwest China region.

3.3. PFOS environmental risk assessment

In order to take an overall environmental risk assessment of PFOS in China based on the inventory of sources and releases for PFOS above, EUSES (European Union System for the Evaluation of Substances) model at its version of 2.1.1 (Vermeire et al., 2005) was applied in this study. EUSES model was developed by European Union as a simple, common risk assessment tool for chemicals (EC, 2003; Vermeire et al., 1997), which can be modified through parameters localization in different countries (Kawamoto and Park, 2006; MacLeod et al., 2001). For such an modeling application, a series of environmental parameters of EUSES model were modified to adapt with relevant situations in China, mainly including the rate of sewage treatment, frame parameters of sewage treatment plants (STP), environmental media information and geographical features in local scale and regional scale (NBS, 2009). Since the PFOS production and use were dominantly distributed in the south-east half part of China representing the core area of the country with industrialization and social-economic development, the study just

Table 1
Releases of PFOS to environmental mediums during manufacture, industrial use and formulation in a local scale.

	Medium	PFOS manufacture	Industrial use and formulation of PFOS		
			Metal plating	AFFFs	Sulfluramid
Local scale[a]	Air	315.6 kg/y	–	1.76 kg/y	15.0 kg/y
	Water	525.0 kg/y	2.88 kg/y	35.3 kg/y	120 kg/y
	Soil	–	–	–	0.60 kg/y

[a] A PFOS producer or a company for PFOS formulation and industrial use. i.e.: a chromium metal plating plant, AFFFs synthesis company, sulfluramid formulation company.

Table 2
Regional environmental releases of PFOS during production and uses in China.

	Manufacture (t/y)	Metal plating (t/y)	AFFFs (t/y)	Sulfluramid (t/y)	Emission strength[g] (g/km^2.y)
Northeast China[a]	–	4.077	1.141	0.021	6.616
Central-north China[b]	–	7.503	1.207	0.002	15.04
Central China[c]	0.715–2.177	2.801	1.061	0.171	9.727
Southwest China[d]	–	0.568	0.854	0.100	1.352
East China[e]	0.126–0.384	15.69	2.283	1.535	24.45
South China[f]	–	3.734	0.823	0.807	11.85

[a] Including Liaoning, Jilin, Heilongjiang Provinces.
[b] Or Middle-north China. including Beijing, Tianjin, Hebei, Shanxi, Shaanxi Provinces.
[c] Including Henan, Hubei, Hunan Provinces.
[d] Including Chongqing, Sichuan, Guizhou, Yunnan Provinces.
[e] Including Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong Provinces.
[f] Including Guangdong, Guangxi, Hainan Provinces.
[g] Release amount of PFOS in per km^2 area per year.

Table 3
Predicted no effect concentrations (PNEC) and the predicted environmental concentrations (PECs) in local level for PFOS in water (ng/l), sediment (ng/g dry wt), soil (ng/g dry wt); Risk characterization ratios (RCR = PEC/PNEC) of PFOS in local level.

	PNEC	PEC_{local}(RCR)			
		Manufacture	Metal plating	AFFFs	Sulfluramid
Water	2.5×10^4	7.82×10^4(3.128)	4.88×10^2(0.019)	5.31×10^3(0.212)	1.79×10^4(0.716)
Sediment	335	555(1.657)	3.45(0.010)	37.6(0.112)	127(0.379)
Soil	373	8.69×10^4(232.9)	4.77×10^2 (1.279)	5.84×10^3(15.66)	1.99×10^4(53.35)

tailor the domain of Chinese territory and defines the South-East half part of China with the six classified regions (just except Tibet, Xinjiang, Qinghai, Gansu, Ningxia, Inner Mongolia Provinces) as the continental background area for the environmental risk assessment of PFOS, so as to make model results more precise and practical. The environmental risk assessment of PFOS was done both in the local scale and regional scale according to different release scenarios of PFOS pollution sources, in which the situation of PFOS source and releases in China around 2008 was used as the baseline.

4. Result and discussion

Tables 3 and 4 showed that the predicted environmental concentrations (PECs) calculated from EUSES model and risk characterization ratios (RCRs) of PFOS in water, sediment and soil in local and regional scale, as well as predicted no effect concentrations (PNEC) (Brooke et al., 2004; OECD, 2002). Available PFOS environmental monitoring data in the six regions was also shown in Table 4 for model results validation and comparison.

In local scale, PECs of PFOS in environment around a PFOS producer, a metal plating plant, companies for AFFFs and sulfluramid were estimated as shown in Table 3. For PFOS manufacture, PECs in water, sediment and soil of the environment around the manufacturer all exceeded the relevant PNECs, showing significant environmental risk of PFOS around its manufacture. Meanwhile, PECs of PFOS in the soil around the metal plating process and the manufacture of AFFFs and sulfluramid using PFOS, were all higher than PNEC, reflecting there were risks in the soil environment around such PFOS using point release sources, However, PECs of PFOS in local water and sediment around the PFOS using release sources were lower than PNECs showing no significant environmental risk there.

In regional scale, as shown in Table 4, the model estimated PECs of PFOS in environmental compartments of each of six regions were compatible with relevant PFOS environmental monitoring data currently available in China generally. Central-north China and Northeast China classified in this study are the major petroleum-chemical and mechanical industry distributed region where maintains large amount of metal plating processes and AFFFs usage with PFOS as shown in Fig. 2. Central-north China ranks the second PFOS emission strength among six regions as shown in Table 2. In Central-north China region, the PECs of PFOS in water, sediment and soil were estimated at 42.5 ng/l, 0.785 ng/g dwt and 0.245 ng/g dwt respectively. In comparison with monitored concentration in this region, the PEC of PFOS in water was higher than monitored concentration in guanting reservoir, Haihe River in Tianjin Province and Beijing (Lu et al., 2011b; Sun et al., 2011; Zhao et al., 2007), but was basically consistent with the monitor data in Dagu Drainage River (Sun et al., 2011). There was no significant difference between the PEC and monitored concentration of PFOS in sediment (Lu et al., 2011a; Sun et al., 2011), while the PEC in soil was a little bit lower than the monitored concentration obtained in Tianjin and north Bohai Sea area (Lu et al., 2011a; Pan et al., 2011). In Northeast China region, the PECs of PFOS in water, sediment and soil were estimated at 17.1 ng/l, 0.315 ng/g dwt and 0.158 ng/g dwt respectively. All of them were lower than those in Central-north China. The PEC of PFOS in water was a little bit higher than the monitored concentration obtained in Liao River (Zhu et al., 2011) and Dalian coastal water (Jin et al., 2008), but in line with anther monitoring concentration obtained in Liaoning Province (Wang et al., 2011). The PEC of PFOS in sediment was fairly compatible with the

Table 4
Predicted environmental concentrations (PECs) in water (ng/l), sediment (ng/g dry wt), soil (ng/g dry wt) and risk characterization ratios (RCRs) of PFOS in regional scales and environmental concentration (EC) from other monitoring data in China.

Regional scale	Compartment	This study	Relevant research	
		$PEC_{regional}$ (RCR)	EC (monitoring)	References
Northeast China	Water	17.1(6.84E−04)	nd−31.0	(Lam et al., 2009; Zhu et al., 2011; Jin et al., 2008; Wang et al., 2011)
	Sediment	0.315(9.43E−04)	nd−1.97	(Jin et al., 2009; Zhu et al., 2011; Lu et al., 2011a)
	Soil	0.158(4.24E−04)	nd−0.702	(Lu et al., 2011a)
Central-north-China	Water	42.5(1.70E−03)	nd−72.5	(Lu et al., 2011a,b; Sun et al., 2011; Zhao et al., 2007)
	Sediment	0.785(2.34E−03)	nd−7.32	(Sun et al., 2011; Lu et al., 2011a)
	Soil	0.245(6.57E−04)	nd−2.36	(Pan et al., 2011; Lu et al., 2011a)
Central China	Water	24.8(9.92E−04)	<0.01−14.0	(Yamashita et al., 2007; Jin et al., 2006)
	Sediment	0.460(1.37E−03)	–	–
	Soil	0.228(6.11E−04)	–	–
Southwest China	Water	4.98(1.99E−04)	nd−0.35	(Yamashita et al., 2007)
	Sediment	0.09(2.73E−04)	–	–
	Soil	0.049(1.30E−04)	–	–
East China	Water	59.0(2.36E−03)	0.33−394	(Lam et al., 2009; Zhu et al., 2011; Yamashita et al., 2007)
	Sediment	1.09(3.27E−03)	0.06−8.78	(Jin et al., 2010; Zhu et al., 2011; Zhang et al., 2010)
	Soil	0.451(1.21E−03)	8.58−10.4	(Zhang et al., 2010)
South China	Water	29.6(1.18E−03)	0.9−99	(Lam et al., 2009; Yamashita et al., 2007)
	Sediment	0.55(1.64E−03)	<0.12−3.10	(Jin et al., 2010)
	Soil	0.285(7.64E−04)	–	–

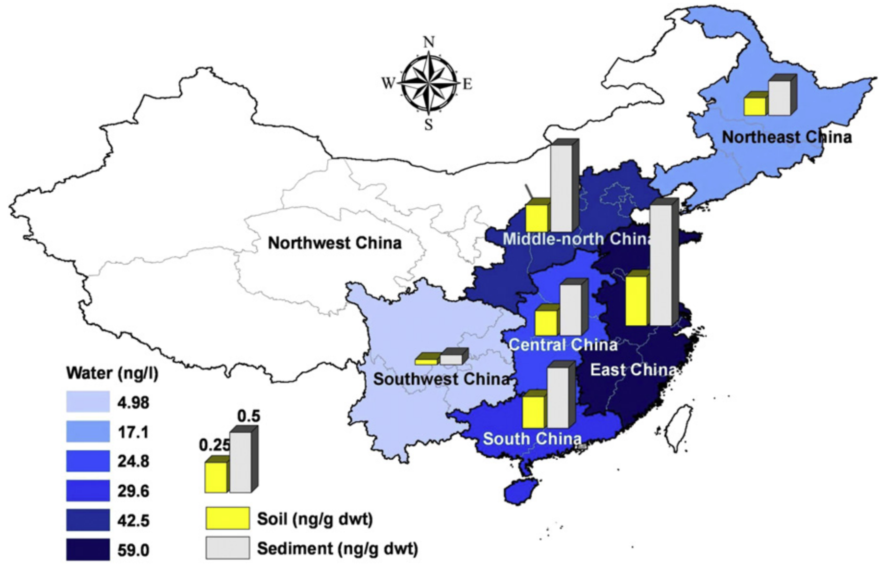

Fig. 3. The concentration distribution of PFOS in water, sediment and soil mediums in six evaluated regions in South-East half part of China. (Each area of blue represents the size of each evaluated region, and darkness of the blue color reveals the PEC values in regional water environment. The yellow column indicates the PEC value of regional soil environment, and the gray column for sediment.) (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

monitoring concentrations obtained in this region (Jin et al., 2009; Zhu et al., 2011), while The PEC in soil was also in line with the range of the monitored concentration from the only one case study in this region (Lu et al., 2011a). In general, in such an area with intensive petroleum-chemical and mechanical industry distributed region and large amount of metal plating processes and AFFFs usage with PFOS in Central-north and Northeast China, the model predicted environmental concentrations of PFOS were consistent with substantive environmental monitoring data of PFOS both in the regions, which could reflect the real environmental risk status of PFOS in this part of territory of China.

Central China and Southwest China regions are a bit less developed region among the six regions, where there was not enough environmental monitoring date of PFOS for making validation and comparison for model results. The PECs of PFOS in water, sediment and soil were estimated at about 24.8 ng/l, 0.460 ng/g dwt and 0.228 ng/g dwt respectively in Centre China region, and at about 4.98 ng/l, 0.09 ng/g dwt and 0.049 ng/g dwt respectively in Southwest China region. Higher PEC of PFOS in water was estimated in Central China region, since the region served as the major PFOS manufacture area of China though there were not so many PFOS using sources like Central-north, South and East China regions. PECs of PFOS in sediment and soil in these two regions were the first reported PFOS pollution concentrations, since there are no monitoring data of PFOS of that area so far.

South China is another important highly industrialized region of China, ranking the third regional PFOS emission strength among six regions as shown in Table 2. PECs of PFOS in water, sediment and soil of this region were estimated at about 29.6 ng/l, 0.55 ng/g dwt and 0.285 ng/g dwt respectively. While PEC of PFOS in water was in the range of the monitored concentrations available in the region, PEC and the monitored concentration of PFOS was fairly closed to each other (Lam et al., 2009; Yamashita et al., 2007). However, there was no monitored concentration of PFOS in soil of South China.

East China is the most developed region of China with highest intensive PFOS emission strength as shown in Table 2. The PECs of PFOS in water, sediment and soil were estimated at about 59.0 ng/l, 1.09 ng/g dwt and 0.451 ng/g dwt respectively, and each of all was higher than those in other regions. PEC of PFOS in water was higher than the monitored concentration from Yangtze River in the range of Nanjing and Shanghai (Yamashita et al., 2007), but was compatible with another monitored PFOS concentration in Taihu-lake (Zhu et al., 2011). PEC of PFOS in sediment was fit well to the monitored level of PFOS in this region (Jin et al., 2010; Zhang et al., 2010; Zhu et al., 2011), while the PEC of PFOS in soil was lower than a monitored concentration in Shanghai (Zhang et al., 2010).

In summary, the model predicted regional environmental PFOS levels of the six regions of the south-east half part of China were shown in Fig. 3, in which regional PFOS concentrations in water were described in different darkness of blue color since water was normally the most representative environmental medium for environmental risk of PFOS. In the environment of this dominant area of China with intensive industrialization and advance social-economic development, the PFOS pollution levels were about 4.98–59.0 ng/l in water, 0.09–1.09 ng/g dwt in sediment and 0.049–0.451 ng/g dwt in soil compartment, which were compatible with relevant monitoring concentrations currently available. Regional environmental pollution levels mentioned above were not exceed the relevant PNEC values currently defined, so that it was difficult to conclude there was environmental risk of PFOS in regional level of China. However, it could reflect an overall environmental risk level of PFOS of China in risk assessment scenario of such an internationally concerned perfluorochemicals.

5. Conclusion

China maintains a PFOS production level at about 100 t/y currently. PFOS are mainly used for metal plating, aqueous fire-fighting foams (AFFFs) and sulfluramid, with the use amount at about 30–40 t/y, 25–35 t/y and 4–8 t/y respectively. Historical intensive use of PFOS in textiles has already ceased due to the international restriction of such applications. The Use amount of PFOS is very limited in semi-conductors, aviation and other application sectors. PFOS manufacture and its using products and industrial processes are mainly distributed in the South-East half part of China, where just represents the dominant area of China with intensive industrialization and advanced social-economic development.

The Environmental releases of PFOS during manufacture were quite intensive, causing significant risk of PFOS in all the environmental compartments around its manufacture plant. Meanwhile, the continuous releases from the processes of metal plating and the manufacture of AFFFs and sulfluramid using PFOS also should not be underestimated, which would cause significant risks in the soil environment around places with those PFOS using processes.

Among the six classified regions in the South-East part of China, East China showed the highest regional emission strength of PFOS, which followed by Central-north China, South China, Central China, Northeast China and southwest China region. The same distributing pattern was reflected in the regional environmental concentration level in the same areas predicted by using EUSES model. The model predicted PFOS pollution level, and was at about 4.98–59.0 ng/l in water, 0.09–1.09 ng/g dwt in sediment and 0.049–0.451 ng/g dwt in soil compartment, which were fairly compatible with relevant monitoring concentrations currently available, reflecting an overall environmental risk level of PFOS of China in risk assessment scenario of such an internationally concerned perfluorochemicals.

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