Endosulfan Meets the POPs Screening Criteria

Pesticide Action Network (PAN) International
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Endosulfan, including both isomers, fulfils the screening criteria specified in Annex D of the Stockholm Convention. Sources of scientific information include critical reviews prepared by recognized authorities and peer-reviewed scientific publications.

Evaluation of Endosulfan against the criteria of Annex D

1. Persistence

Annex D screening criteria

(i) *Evidence that the half-life of the chemical in water is greater than two months, or that its half-life in soil is greater than six months, or that its half-life in sediment is greater than six months; or*

(ii) *Evidence that the chemical is otherwise sufficiently persistent to justify its consideration within the scope of this Convention;*

Evidence

(i) The half-life in water is reported to be from 1 month to 6 months under anaerobic conditions (ATSDR 2000); the half-life in a water/sediment microcosm in a Brazilian wetland has been measured as more than 2 months (Laabs et al 2007); the half-life in soil of total endosulfan under aerobic conditions has been reported as 44.5 months (US EPA 2007c), and up to 6 years (GFEA-U 2007).

(ii) Field studies in India and Australia where endosulfan was used on cotton crops have shown that residual levels in the soil at the beginning of the season are higher than they were at the beginning of the previous season indicating a continual build-up in the soil (Kennedy et al 2001; Jayashree & Vasudevan 2007b; Vig et al 2008).

Endosulfan's persistence has resulted in it becoming a ubiquitous global contaminant of soil, sediment, fresh and marine waters, aquatic and terrestrial biota, and human food.

Conclusion: There is sufficient evidence that Endosulfan meets the persistence criterion.

2. Bio-accumulation

Annex D screening criteria

(i) *Evidence that the bio-concentration factor or bio-accumulation factor in aquatic species for the chemical is greater than 5,000 or, in the absence of such data, that the log K_{ow} is greater than 5;*

(ii) *Evidence that a chemical presents other reasons for concern, such as high bio-accumulation in other species, high toxicity or ecotoxicity; or*

(iii) *Monitoring data in biota indicating that the bio-accumulation potential of the chemical is sufficient to justify its consideration within the scope of this Convention*;

Evidence

(i) Although estimates of log K_{OW} are slightly less than 5 (4.65 for alpha and 4.34 for beta endosulfan) (GFEA-U 2007), a bioconcentration factor of >11,000 has been recorded for at least one aquatic species (Jonsson & Toledo 1993).

(ii) Additionally, endosulfan has an even greater potential to bioaccumulate in terrestrial species than in aquatic species because of its high log K_{OA} (>10 for alpha and beta isomers), with predicted biomagnification factors in wolves of 5.3 at age 1.5 years, 17.9 at 2.25 years and of 39.8 at 13 years (Kelly & Gobas 2003, supporting data). The biomagnification factor for other herbivorous and carnivorous terrestrial species is calculated as ranging from 2.5 to 28 (Kelly et al 2007).

(ii) Monitoring data have shown increasing concentrations of endosulfan in age-adjusted beluga (Braune et al 2005), and in freshwater char (Evans et al 2005). There is evidence of bioaccumulation in fish in Argentina, with a biomagnification factor greater than that for DDT and most other POPs (Menone et al 2000), and in rats (Kuvarega & Taru 2007). There is evidence of bioconcentration in plants too: in bulrushes with a bioconcentration factor higher than that for DDT (Miglioranza et al 2004b), in grasses (Wang et al 2007a), and in conifer needles—where total endosulfan in two-year old needles was three times higher than those in one-year old needles (Landers et al 2008). There is evidence of bioaccumulation resulting from maternal transfer of endosulfan in elephant seals in Antarctica, where significantly higher relative proportions were found in the pups compared with the adults (Miranda-Filho et al 2007).

Endosulfan residues are also commonly found in human placental tissue, umbilical cord blood and breast milk, and endosulfan is transferred to the foetus and newly-born infant (Cerrillo et al 2005; Fukata et al 2005; Damgaard et al 2006; Torres et al 2006; Shen et al 2007, 2008; Pathak et al 2008). Residues of endosulfan in breast milk in Bhopal, India in 2003 were 8.6 times the average daily intake levels recommended by the World Health Organisation (Sanghi et al 2003). At least some of the residues in humans are believed to have resulted from the consumption of food containing residues of endosulfan (Campoy et al 2001; Sanghi et al 2003; Carreno et al 2007).

Conclusion: There is sufficient evidence that Endosulfan meets the bioaccumulation criterion.

3. Potential for long-range environmental transport

Annex D screening criteria

(i) *Measured levels of the chemical in locations distant from the sources of its release that are of potential concern;*

(ii) *Monitoring data showing that long-range environmental transport of the chemical, with the potential for transfer to a receiving environment, may have occurred via air, water or migratory species; or*

(iii) *Environmental fate properties and/or model results that demonstrate that the chemical has a potential for long-range environmental transport through air, water or migratory species, with the potential for transfer to a receiving environment in locations distant from the sources of its release. For a chemical that migrates significantly through the air, its half-life in air should be greater than two days.*

Evidence

(i) Residues of endosulfan have been found in biota and in environmental media at locations far distant from where it has been released. It has been found in biota and ice in both the Arctic (Vorkamp et al 2004; Kelly et al 2007; Stern et al 2005) and Antarctic (Miranda-Filho et al 2007). It has been found in grasses on Mt Qomolangma (Everest) region of the Tibetan Plateau (Wang et al 2007a) and in spruce needles of the Central Himalayan region (Wang et al 2006b); in lichen in the Canadian Rockies (Daly et al 2007a), and in lichen and conifers in the western national parks of the USA (Landers et al 2008).

(ii) Endosulfan has been consistently measured in air all over the world, including in remote locations in the Arctic, high mountain areas in Asia (Himalayas), Europe, and North America, as well as tropical mountains in Costa Rica. Levels of endosulfan in the air are frequently amongst the highest of the pollutants measured. The Global Air Passive Sampling study resulted in a geometric mean value of 62 pg/m^3 for total endosulfan, well above the next most abundant, PCPs with a mean of 17 pg/m^3. In the polar regions endosulfan levels (2.0 pg/m^3) were second only to PBDEs (3.7 pg/m^3), and well above DDT (0.5 pg/m^3), dieldrin (0.14 pg/m^3) and the other POPs (Pozo et al 2006).

It has also been consistently measured in precipitation: in snow in the Canadian Arctic (Tuduri et al 2006) and US national parks (Hageman et al 2006; Mast et al 2007), as well as in ice in the Italian Alps (Herbert et al 2004) and Antarctica (Deger et al 2003); and in rain in Asia (Kumari et al 2007), Africa (GEF SSA 2002), Europe (Carrera et al 2002; Quaghebeur et al 2004; Scheyer et al 2007), North America (Kuang et al 2003; Carlson et al 2004; Sun et al 2006; Tuduri et al 2006; Brun et al 2008), and Latin America (Laabs et al 2002). Residues of endosulfan in the Caribbean are believed to have resulted from deposition in dust carried from the African Sahara/Sahel region (Garrison et al 2006).

Levels of endosulfan have continued to increase in the Arctic, in beluga (Braune et al 2005) and in air (NCP 2003) at the same time as the levels of most POPs have declined. Similar increases have been observed in the freshwater fish char; residues were 2.2 times higher in 2002 than they were in 1992 (Evans et al 2005).

(iii) Endosulfan is semi-volatile. It evaporates from the surface of soil and plants after application. Laboratory studies indicate 25-30% dissipates from the soil surface over 24hrs, and 64% from plant leaves (GFEA-U 2007). Field studies in Australia have found 70% of endosulfan is lost from cotton fields through volatilisation (Kennedy et al 2001; Sutherland et al 2004). The atmospheric half-life of endosulfan under experimental conditions is 27 days. Experimental measures have found a half-life of endosulfan of > 2.7 days and for beta endosulfan of > 15 days. Measurements at Alert in the Canadian Arctic have shown an atmospheric half-life there of 38 years for alpha endosulfan (Hung et al 2002, 2005).

Conclusion: There is sufficient evidence that Endosulfan meets the criterion on potential for long-range environmental transport.

4. Adverse effects

Annex D screening criteria

(i) Evidence of adverse effects to human health or to the environment that justifies consideration of the chemical within the scope of this Convention; or

(ii) Toxicity or ecotoxicity data that indicate the potential for damage to human health or to the environment.

Evidence

(i) Endosulfan is one of the main causes of poisoning in humans in many countries (Kishi et al 2002; Oktay et al 2003; Roberts et al 2004; Wesseling et al 2005). Many deaths have resulted from occupational and accidental non-occupational exposure, as well as self-poisoning, in a number of countries in Africa, Asia and Latin America (PANNA 1999; EJF 2002; El Hindi et al 2006; GEF CAC 2002; Venkateswarlu et al 2000; Glin et al 2006; Mingxin 2007). Acute effects have also been reported in New Zealand and USA (ERMANZ 2007b; Associated Press 2007).

Chronic effects reported in humans include birth defects, congenital reproductive disorders, long-term brain damage, recurrent convulsions, epilepsy, autism, delayed sexual maturity, endometriosis, menstrual disorders, early menarche, male breast enlargement, various cancers, congenital intellectual disability, cerebral palsy, psychiatric disturbances, and vision impairment and loss (Aleksandrowicz 1979; Pradhan et al 1997; Quijano 2002; NIOH 2003; Saiyed et al 2003; Roberts et al 2007; Venugopal 2008).

Many deaths in animals—including fish, wildlife, pets, and livestock—have also been reported, as well as congenital deformities, miscarriages, infertility, stunting of growth, and dwindling populations (PANNA 1996; Ton et al 2000; GEF CAC 2002; GEF SSA 2002; Quijano 2002; NIOH 2003; Schulz 2004; Glin et al 2006; ERMANZ 2007b).

(ii) Toxicological data indicate that endosulfan is very toxic to mammals by skin contact, inhalation or ingestion (GFEA-U 2007). It causes a range of acute neurological effects, including convulsions and death (ATSDR 2000). It damages the liver and kidneys and is toxic to the adrenal gland and pancreas (ATSDR 2000). It causes oxidative stress (Omurtag et al 2008). It is toxic to and suppresses the immune system (ATSDR 2000; Kannan et al 2000; Pistl et al 2003; Garg et al 2004; Lafuente et al 2006; Narita et al 2007). It depresses testosterone levels and may cause reproductive toxicity in humans (ATSDR 2000). It interferes with the steady state levels of oestrogen causing proliferation of MCF-7 human breast cancer cells, and its effects on the endocrine system indicate that endosulfan is likely to cause the onset and/or development of mammary tumours (Soto et al 1994, 1995; Bradlow et al 1995; Toniolo et al 1995; Berrino et al 1996; Dorgan et al 1996; Andersen et al 2002; Cossette et al 2002; Rousseau et al 2002; Grunfeld & Bonefeld-Jorgensen 2004; Kojima et al 2004; Bonefeld-Jorgensen et al 2005; Wozniak et al 2005; Je et al 2005; Laville et al 2006; Lemaire et al 2006; Wong & Matsumura 2006; Chatterjee et al 2008). It targets the prefrontal cortex of the brain (Cabaleiro et al 2008), and may be implicated in Parkinson’s disease (Wang et al 2006a; Jia & Misra 2007a). It causes adverse behavioural effects (ATSDR 2000). Exposure in utero causes teratogenic effects (Singh et al 2006). Many studies have shown it to be genotoxic and mutagenic in human cells, rodents, hamsters, fruit fly, fish, tadpoles, oysters, bacteria, microalgae and plants (Yadav et al 1982; Sobti et al 1983; Pandey et al 1990; Lu et al 2000; ATSDR 2000; Jamil et al 2004; Lajmanovich et al 2005; Bajpayee et al 2006; Neuparth et al 2006; Pandey et al 2006; Antherieu et al 2007; Perez et al 2007; Sharma et al 2007a; Wessel et al 2007; Akcha et al 2008; Menone et al 2008). It is also a tumour promoter (Fransson-Steen et al 1992; Dubois et al 1996; Warngard et al 1996; ATSDR 2000). Toxicity is increased with protein-deficient diets, which are a problem in some of the countries in which endosulfan is still used.

Endosulfan is very toxic to aquatic organisms especially juveniles, and its use results in disruption of the aquatic food chain. Concentrations of endosulfan found in rivers greatly exceed the hazardous concentrations that adversely affect 5% of fresh water and marine organisms as identified in Bollmohr et al (2007).

It is also toxic to amphibians, reptiles, snails, aquatic plants, coral reef organisms, birds, bees, earthworms, and beneficial insects and microorganisms, and is incompatible with IPM (Elzen 2001; Bostanian & Akalach 2004; Bastos et al 2006; Schneider et al 2006; Alizadeh et al 2007; Benamú et al 2007).

Conclusion: There is sufficient evidence that Endosulfan meets the criterion on adverse effects.

Additional information can be found in the PAN International Submission to the Stockholm Convention secretariat

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