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Growing doubts about the safety of glyphosate

Friends of the Earth Europe, June, 2013

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Introduction

Glyphosate is the world's best-selling chemical herbicide. Glyphosate-containing herbicides, such as Monsanto's Roundup, are the most widely used herbicides in Europe, applied in farming, forestry, parks, public spaces and gardens. Glyphosate-containing herbicides are also crucial to the production of genetically modified herbicide resistant crops. In recent years a number of scientific studies have raised concerns about glyphosate's safety and there have been calls for glyphosate-containing herbicides to be banned. New research by Friends of the Earth has detected glyphosate residues in the urine of 44 percent of people tested, from 18 different European countries.

Growing exposure

Glyphosate was given a European Union approval in 2002, and the European Commission stated that exposure to glyphosate in food or the environment would have "*no harmful effects on human or animal health*" [1]. At the time, the EU authorities set an 'acceptable daily intake' (ADI) of 0.3mg glyphosate per kilogram of body weight per day. This means, for example, that it is considered 'acceptable' for a child weighing 20kg to consume 6mg of glyphosate every day.

Following the authorities' positive assessment of the chemical, glyphosate-containing herbicides have been approved for a wide range of uses, from farms and forestry to public parks and private gardens [2]. Glyphosate now is the most widely used herbicide in European agriculture, and millions of tonnes of genetically modified soybeans treated with glyphosate are being imported into the EU every year.

Gaps in approval

The evidence in support of glyphosate's EU approval came largely from industry-funded trials, and the main focus of study was the pure chemical. Only short term, high dose animal feeding trials have been required for the herbicides in which glyphosate is sold and used.

But pure glyphosate is not used on its own in herbicides; it is always chemically combined, often with isopropylamine (IPA) [3]. Experimental evidence has shown that the IPA salt of glyphosate can be significantly more toxic than pure glyphosate [4].

In addition, the herbicides also contain other chemical ingredients. For example, a class of chemicals called 'surfactants' are added to increase penetration of glyphosate into plant cells. The concentrations and even identities of these extra ingredients are often kept secret, but as early as the 1980s, medical staff dealing with glyphosate poisonings suggested the surfactants could be toxic [5]. European authorities are planning to assess the safety of these other chemical ingredients, but it will be a lengthy process and won't even start until 2014. At present, the chemical mixtures in which glyphosate is sold - and to which European citizens are actually exposed - have not had sufficient safety tests.

Glyphosate-containing herbicides

Monsanto states that its herbicide Roundup has "*very low acute toxicity*" [6], but information from human poisonings shows that swallowing more than 85ml of a glyphosate-containing herbicide can cause severe reactions [7], and may even be fatal [8]. Some brands are much more toxic than others [9], and the toxicity to human cells of different glyphosate-containing herbicides can vary by as much as 150 times [10]. Glyphosate-containing herbicides have been found to be toxic to human cell cultures [11], including human embryonic and placental cells [12], at concentrations far lower than found in herbicide sprays. Experiments also show that the main chemical to which glyphosate breaks down, aminomethylphosphonic acid (AMPA), is more toxic to human cells than glyphosate itself [13].

Complex chemical interactions affect the toxicity of the different glyphosate-containing herbicides. Evidence shows that glyphosate may increase the toxicity of other chemicals in the mix [14], while surfactants may enable glyphosate to enter into cells and so cause toxic effects [15]. In almost every experiment, glyphosate-containing herbicides have been found to be more toxic than pure glyphosate, and detailed studies using human cell cultures have found that herbicide ingredients are more toxic in combination than predicted by the effect of each chemical on its own [16]. Researchers working in this area have commented that the failure of the authorities to consider such mixture effects "*will undoubtedly lead to the underestimation of potential hazards*" [17]. They have also recommended that the

'acceptable daily intake' should be set for each herbicide formulation, rather than for glyphosate alone, because of these complex toxic effects [18].

Glyphosate in the body

People may encounter glyphosate-containing herbicides in the environment or as residues in food. Data from animal experiments suggest that when glyphosate is consumed, 15-30% of it is absorbed into the body [19]. Most of this absorbed glyphosate remains unchanged, and can distribute into the blood and body tissues [20], as well as being able to cross the placenta during pregnancy [21]. A small proportion (<10%) may be converted into AMPA [22]. One week after a single exposure, only 1% of absorbed glyphosate remains, mostly in the colon and in bones [23]. However, because glyphosate is so widely used, it is likely that many people could be having regular and repeated exposure to it (see [briefing 4]).

Glyphosate and endocrine disruption

In recent decades, scientific concern has been growing about chemicals that interfere with hormones in the body at very low doses, called endocrine disrupting chemicals. At particular life stages, such as during pregnancy or puberty, endocrine disrupting chemicals may cause irreversible effects even though there are no obvious signs of toxicity at the time [24]. Investigations into glyphosate suggest it may show endocrine disrupting effects, particularly on reproductive development. For example, in one study pregnant female rats were given a glyphosate-containing herbicide at high doses, but not enough to affect their health or their pregnancies. The reproductive development of their male offspring was altered compared to normal, including lower testosterone levels and reduced sperm production as adults [25].

Evidence from cell culture (*in vitro*) studies show that glyphosate blocks receptors for male sex hormones [26], while glyphosate-containing herbicides reduce testosterone production in male reproductive cells [27] and inhibit the production of other hormones [28]. The endocrine disrupting effects of glyphosate-containing herbicides have been observed in cells at concentrations down to 0.2 parts per million (ppm) [29]. Both glyphosate and Roundup have been found to disrupt a biological pathway involved in the production of oestrogen [30] [31], and human embryonic cells were particularly sensitive to this effect, leading researchers to conclude that "*exposure may affect human reproduction and fetal development*."[32]

Such findings from cell culture studies have been called irrelevant by the industry and by EU authorities. The German government has stated that evidence gained from studies using laboratory mammals is "*considered of superior quality and reliability as compared to in vitro data*"[33]. But the Endocrine Society, which represents specialist scientists from around the world, has stated that endocrine disruption does not occur in the same way as other forms of toxicity, and that "*data derived from the traditional [animal based] approach … will have a high probability of underestimating potency and may miss important effects altogether*."[34]

Glyphosate and Birth Defects

In the last decade some South American countries have seen huge increases in the production of genetically modified glyphosate-resistant crops, and reports from these areas raise worrying concerns about glyphosate. In the Chaco province of Argentina, where GM glyphosate-resistant soybeans are heavily grown, there has been a threefold increase in birth defects in the last decade [35]. The province of Cordoba is top ranked for GM glyphosate-tolerant crop production in Argentina, and it also has the highest rates of birth defects in the country [36]. A study at a Paraguayan hospital in 2006/7 found that women living within 1km of pesticide-sprayed soybean fields were more than twice as likely to have a baby born with a birth defect [37]. And studies of farming families in North America have found links between glyphosate use and lower rates of conception [38], higher rates of miscarriage [39] and higher rates of attention deficit hyperactivity disorder (ADHD) in children [40].

Following such concerns, a group of Argentinean researchers published research findings that embryos of frogs and chickens showed cranial malformations when exposed to dilutions of glyphosate-containing herbicides [41], with one herbicide still causing effects when it was diluted to 2 parts per million [42]. Effects were also observed when the embryos were exposed to pure glyphosate. Further investigations suggested the malformations could be due to disruptions in a genetic pathway important for the developing brain and facial portions of the skull. The same genetic pathway is present in humans. Other studies have found that glyphosate-containing herbicides can cause malformations in tadpoles [43] at levels found in the environment [44].

The industry and European authorities have largely dismissed these findings. In 2010 the German competent authority BVL, which led the EU's assessment of glyphosate, stated there is a "*huge and reliable database*" on glyphosate's safety [45]. But in 2012, a review of industry-funded studies on glyphosate was conducted by scientists (including four professors) from universities in the UK and Brazil [46]. They noted that industry studies had also found birth defects in the offspring of animals fed doses of pure glyphosate, including heart and skeletal malformations. They pointed out that many of the birth defects could have been caused by disturbance to the same genetic pathway identified by the Argentinean researchers. The group commented that attempts to dismiss concerns about birth defects were "*unconvincing*", and they accused EU authorities and industry of ignoring or misinterpreting critical findings during glyphosate's approval process.

Glyphosate and DNA damage

Within organisms, cells are constantly reproducing and a crucial part of this is the accurate copying of DNA. Some chemicals, called genotoxic, interfere with this process. They may change DNA, chromosomes or the nucleus of the cell in ways that have the potential to cause genetic mutations or increase cancer risk [47]. Cell culture tests using glyphosate and its breakdown product, AMPA, have found both chemicals to be genotoxic [48]. Chromosome aberrations have been observed in bone marrow cells of mice exposed to high doses of glyphosate [49], and the presence of glyphosate-containing herbicides in water has been found to cause DNA damage to frogs [50], fish [51], and caiman [52].

In areas of Ecuador and Colombia, aerial spraying with glyphosate-containing herbicides was used during the last decade to control cocaine production. A study of people living in Ecuador found genetic damage and increased rates of miscarriage during the spraying period [53], while a study in Colombia found low rates of genotoxic effects on local populations [54].

Findings of DNA damage do not necessarily predict cancer or genetic mutations. But a Swedish epidemiological study has found links between use of glyphosate by farm workers and later development of certain types of leukaemia [55]. In the Chaco province of Argentina, where GM glyphosate-tolerant soybeans are heavily grown, there has been a fourfold increase in cancer in the last decade [56]. Recently, a controversial animal study found

increased rates of cancer in rats fed for two years with a diet of GM maize grown with a glyphosate-containing herbicide, and also in rats fed a non-GM maize diet with glyphosate herbicide added [57]. Industry-funded trials usually only last for 90 days, and the cancers did not appear until after this time. The methods used by the researchers have been criticised by EU authorities, but scientific advisors to the Belgian government commented that a "*major result of this paper is that the (potential) occurrence of problems takes time well above the usual duration of this type [of feeding trial]*". They recommended longer term feeding trials, and follow up studies [58].

Conclusions and demands

New research from Friends of the Earth has shown that people from all over Europe – in EU and none EU countries – have glyphosate residues in their urine. The evidence suggests that a significant proportion of the population could have glyphosate in their bodies – and it is not clear where it is coming from. Despite the fact that glyphosate is the world´s best-selling chemical herbicide and glyphosate-containing herbicides are the most widely-used herbicides in Europe, very little testing is done for glyphosate residues in food, feed, or water. Tests for glyphosate in the body do not take place at all.

Friends of the Earth wants to know:

- Why do people have glyphosate in their urine? Where does it come from?
- Why haven´t public authorities done any testing on glyphosate residues in humans?
- Why is food, animal feeds (such as imported soy) and drinking water so rarely tested for glyphosate?
- What are the health impacts of glyphosate in our bodies? Is it guaranteed that glyphosate residues are completely excreted? If not, what happens to the remaining residues?
- Why haven´t there been any long-term health studies on on-going glyphosate uptake in humans?
- Why have the maximum residue levels (MRLs) for glyphosate in food and feed been steadily increased?
- Who is profiting from increasing glyphosate use?
- Why are authorities considering applications to grow glyphosate-resistant genetically modified crops in Europe?

Given the uncertainty about how glyphosate is entering people and the need to minimise exposure to glyphosate, Friends of the Earth demands that:

- The EU and national governments must immediately start a monitoring programme for glyphosate in food and feed, including imported animal feed crops such as GM soy. Levels of glyphosate (and its breakdown product AMPA) in the environment should also be monitored, covering aquatic systems and soil. These monitoring programmes should be comprehensive and the results should be made available to the public without delay.
- National governments must introduce a glyphosate reduction programme and desiccation (spraying crops shortly before the harvest) should be banned without delay. All other uses for glyphosate should be evaluated by 2015, existing maximum residue limits (MRLs) should be re-evaluated, and there must be no further increases in the MRLs.
- No glyphosate resistant genetically modified crops should be authorized in the EU.
- All food processors and retailers should minimise their customer´s exposure to glyphosate residues by specifying glyphosate-free products from their suppliers. They should extend their internal pesticides monitoring programme and include glyphosate in their regular testing.

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