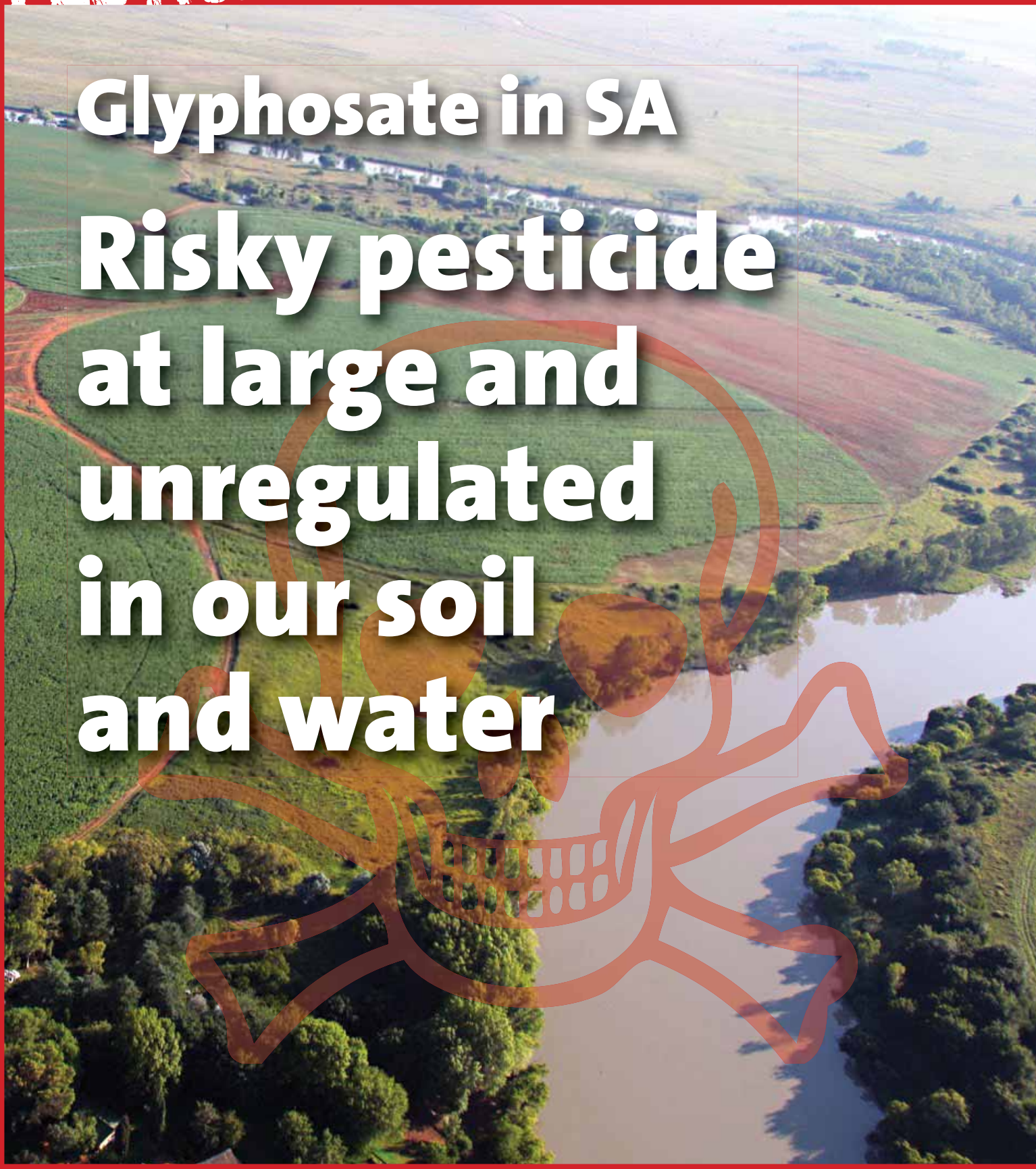
PESTICIDES AND GM CROP SERIES



Glyphosate in SA

Risky pesticide at large and unregulated in our soil and water

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CONTENTS

ACRONYMS

AMPA	aminomethylphosphonic acid
AVCASA	Association of Veterinary and Crop Associations of South Africa
DAFF	Department of Agriculture, Forestry and Fisheries
CSIR	Council for Scientific and Industrial Research
DWA	Department of Water Affairs
EU	European Union
FSE	Farm Scale Evaluations (UK)
GBH	Glyphosate based herbicide
GMO	Genetically Modified Organism
LPx	lipid peroxidation
MRL	Maximum residue level
NTMP	The National Toxicity Monitoring Programme
SANBI	South African National Biodiversity Institute
WRC	Water Research Commission

INTRODUCTION

This paper is the second in a series focusing on the ubiquitous agricultural chemical, glyphosate, which is the active ingredient in numerous formulations of herbicides. Today it is the world's biggest selling agro-chemical. The development of glyphosate tolerant genetically modified (GM) crops has ensured that glyphosate continues to hold a central place in the global industrial agricultural system, including in South Africa. In 1980, herbicides accounted for 14% of global pesticide production. By 2005 this figure had increased to 49%. Glyphosate now accounts for 25% of the global herbicide market.[1]

The impacts of agricultural pesticides on the environment have been well documented for a number of years. This year marks 50 years since the publishing of Rachel Carson's seminal book 'Silent Spring'. The book's impact in the United States was far-reaching; more than 40 bills were introduced to regulate chemical use within a few months of the book's publication. Indeed, Carson's book is seen as one of the founding texts of the environmental movement.[2] Paradoxically, in an age when environmental awareness has never been greater, the pesticide industry has grown bigger than ever before.

The political economy of glyphosate and the recent phenomenon of glyphosate resistant weeds (and the biotechnology industry's response to this) will be discussed in forthcoming ACB research papers. To date, we have published a paper titled "How much glyphosate is on your dinner plate? SA's food safety compromised by lack of testing." In that paper, we look at the risks that glyphosate poses to human and animal health, and reveal the shocking lack of testing for pesticide residues in our nation's food supply. The focus of this paper will be on the environmental impacts of glyphosate, and to what extent if any, there is proper monitoring and management of the environmental risks posed by glyphosate.

USE OF TERMS

Please take note that throughout this paper we refer to 'glyphosate', 'glyphosate-based herbicides (GBH)' and 'Roundup'. Glyphosate is the active ingredient which kills the plant it is applied to. However, glyphosate needs to be combined with other chemicals, known as adjuvants and surfacants, in order for it to be effective.[3] The term GBHs, of which Monsanto's brand 'Roundup' is best known, refers to the commercially available formulations of herbicides in respect of which glyphosate is the active ingredient (as opposed to for example, herbicides based on 2,4-D or Dicamba). For this reason, in many of the experiments cited in this paper, researchers have tested for the effects of glyphosate on its own and GBHs (including Roundup). Aminomethylphosphonic acid (AMPA) is the main chemical product found as glyphosate breaks down in the environment.

KEY FINDINGS

1. Glyphosate was first registered in South Africa in 1975. It is most commonly used in agricultural crop production, though it is also used as a weed-killer along roadsides, railway lines and in managed aquatic systems. Glyphosate has become synonymous with genetically modified (GM) crops and. Though insect resistant (Bt) crops were initially the principally adopted GM

crops, herbicide tolerant maize now accounts for 50% of all GM maize planted in South Africa. HT soya cultivation rose from 165,000 ha in 2008 to 472,000 ha in 2012. Over a similar period (2005 – 2012), the overall use of glyphosate has increased from 12 million litres to 20 million litres. Similarly, from 2007 to 2011 glyphosate imports increased by 177%.

2. Between 10-30% of pesticides applied on the ground never reach their target organism. For sprayed pesticides the figure is between 50 – 70%. As such, its impact on non-target organisms is substantial. Numerous studies have revealed that glyphosate, and glyphosate based herbicides (GBH): have been linked to increased incidences of over 30 plant diseases, can inhibit nutritional uptake in plants, is toxic to earthworms and contributes significantly to incidences of fungal disease. Glyphosate's impact on weed diversity has knock on effects higher up the food chain, including on butterfly and bird populations.
3. The pesticide industry claims that because glyphosate tends to bind to particles in the soil, the risk of it reaching surface water sources is minimal. However, studies conducted in both the USA and Europe have detected high concentrations of both glyphosate and its main breakdown product, aminomethylphosphonic acid (AMPA) in groundwater sources, with considerable implications for drinking water supplies. Glyphosate's ability to bind in soils is also influenced by the presence of phosphorous, which is used extensively in industrial agriculture as a synthetic fertiliser.
4. Glyphosate is highly soluble in water, giving it the capacity to be highly mobile in aquatic systems. Once mobile in water, research has shown that GBHs cause considerable damage to populations of amphibians, and is toxic to numerous aquatic organisms, including phytoplankton and freshwater mussels. The results of a study published earlier this year, led its author to conclude that 'this is the first study to show that a pesticide can induce morphological changes in a vertebrate.'[4]
5. South Africa's hopelssly dated legislation regulating pesticides[5] has not been comprehensively overhauled or updated since its enactment in 1947. A Pesticide Management policy was published by the Department of Agriculture, Forestry and Fisheries (DAFF) in 2010, which recognises that current legislation does not provide adequate measures to monitor the environmental impact of pesticides; neither does it provide for the protection of non-target areas (such as residential areas or schools). Experts who commented on the policy noted that the policy paid scant attention to the protection of water sources.
6. The right to a healthy environment, and to sufficient and safe water, is enshrined in the South African Constitution. Further, the National Water Act (Act.36 of 1998) requires the Minister of Water Affairs to establish systems to monitor the health of our nation's water resources. It is staggering to note that there are no water quality standards to protect the country's freshwater systems, or indigenous freshwater organisms, from GBHs. Neither is there a national maximum residue level (MRL) set for glyphosate in water sources.
7. The Department of Water Affairs (DWA) and the Council for Scientific and Industrial Research (CSIR) have both conducted water monitoring projects for pesticides. Regrettably, neither of them focused on glyphosate or GBHs. Researchers at Rhodes University have been attempting to fill this knowledge gap by using Fresh-water Shrimp (*Caridina nilotica*) as a biomarker for the potential impact of GBHs in aquatic systems. Initial studies have concluded that even low levels of Roundup may adversely affect this species. It is imperative that government dedicate more resources to studying and protecting our water resources (already recognised as extremely stressed) from the effects of GBHs.

8. The South African National Biodiversity Institute (SANBI) is in the very early stages of formulating an environmental monitoring project for glyphosate tolerant genetically modified (GM) crops. However, the project's lead person has subsequently left SANBI, leaving the fate of such a study uncertain. In 1999 the UK government conducted a similar study, which highlighted a number of impacts that glyphosate tolerant crops could have on biodiversity.

GLYPHOSATE USE IN SA

Glyphosate was first registered in South Africa in 1975[6], and is used as a weedkiller in a wide variety of settings, including municipal weed management (such as road sides or along railway lines), but it is in agriculture where it has become 'ubiqitous'. It has been used in the vineyards of the Western Cape for more than 30 years[7], and is registered for use with crops as diverse as apples, bananas, macadamia nuts and sugarcane. The three genetically modified (GM) crops commercially cultivated in South Africa, maize, cotton and soybean, all have varieties that are tolerant to glyphosate.

Accurate figures of pesticide applications throughout South Africa are extremely difficult to come by as Croplife, the pesticide industry association, no longer keeps statistics on this.[8] Neither does the Department of Agriculture, Forestry and Fisheries. However, import data from the United Nations indicates that imports of glyphosate increased 177% between 2006 and 2011. Overall glyphosate rose from 12 million litres in 2006 to 20 million litres at present.[9]

http://static2.aif.ru/public/news/big/382/3823cefed5483b5839a2b12a2732395d.omsk.jpg

Over the same period South Africa's commercial farmers have rapidly embraced herbicide tolerant (HT) crops. The first HT cotton variety was commercially released in South Africa in 2000, followed by HT varieties of soybean and maize in 2001 and 2002 respectively. Adoption rates for HT maize hovered around the 30% mark but increased markedly to over 50% in 2010/11.[10]

In the 2011/2012 season, about 72% of all maize seed sold in South Africa was GM, of which at least 50% was ht (either as a single trait, or stacked with insect resistance). The latest available data shows that 95% of the cotton now planted in South Africa contains the HT gene, though cotton

production in South Africa, which is all GM now, is marginal (equivalent to less than 1% of total GM cropped area). HT soya cultivation has risen from 165,000 ha in 2008 to 472,000 ha in 2012. Experts in the sector predict that over 650,000 ha will be planted in South Africa by the end of the decade.[11]

GLYPHOSATE AND BIODIVERSITY

It is claimed by industry, particularly Monsanto, that glyphosate is a benign herbicide.[12] Numerous scientific studies now refute this. Glyphosate can impact upon plants and animals in the following ways: via direct toxic effects of exposure to spray, chronic effects caused by long term exposure in the eco-system, and indirect effects due to changes in the eco-system.[13] All of these pathways are exacerbated by the fact that a large portion of agro-chemicals never reach the intended target organism: 10-30% of pesticides applied on the ground, rising to 50-75% of sprayed pesticides.[14] Thus, independent data as to the potential effects of glyphosate and GBHs becomes even more important.

The following list of adverse impacts is in no way exhaustive, but nevertheless raises grave concern:

- Research analyzing the impact of Roundup formulations and glyphosate itself, has shown it to have an inhibitory effect on microbial growth at lower concentrations than those recommended in agriculture. The toxic effect of glyphosate was amplified by its formulation adjuvants.[15]
- Glyphosate is generally considered to rapidly 'bind' to soil particles following application in the field, therefore minimising the risk of it leaching from the soil into nearby water. However, glyphosate's ability to bind to soil particles can vary depending upon specific chemical properties (such as soil Ph levels). It is also known that phosphate (which is used extensively in chemical agriculture as a fertiliser) plays a particularly important role in this, though further study will be needed.[16] This could be of particular relevance to South Africa, as phosphate use is expected to increase in accordance with increased grain production within the Republic.[17]
- Various studies have found glyphosate to: impair water intake and use efficiency, and biomass production in plants[18]; interfere with the uptake of calcium, magnesium, iron and manganese in non HT soybeans[19]; and contribute significantly to incidences of fungal disease.[20]
- Glyphosate weed control programmes have been linked to increased incidences of over thirty plant diseases, in crops as diverse as apples, barley, canola, citrus, cotton, soybeans, tomatoes and wheat.[21]
- Greenhouse studies have shown that glyphosate interferes with iron uptake even in glyphosate tolerant soybean plants.[22] A three year field study in the USA indicated that, at rates of 2.52kg/ha, glyphosate inhibits nitrogen fixation and or simulation in glyphosate resistant soybeans.[23]
- In greenhouse and growth chamber experiments, conventional and glyphosate tolerant soybeans were treated with glyphosate doses of 0.28 kg/ha, 1.12 kg/ha and 2.24 kg/ha. A dose of 2.24kg/ha reduced the dry shoot and root weight of glyphosate tolerant soybeans by 25-30%. A repeated dosage reduced root growth, and reduced the nodule number by between 30% and 39%.[24]
- Glyphosate is toxic to earthworms.[25]
- Glyphosate's impact on plant (weed) diversity in areas it is used has knock-on effects further up the food-chain: The rapid spread of GM HT crops in the USA has contributed significantly to 'the potential collapse' of the 'unique migration and overwintering biology of the eastern North American monarch butterfly'.[26] Studies from the USA have also linked its use to declining bird populations (similar results were observed in the UK – see below).[27]

UK Farm Scale Evaluations (FSE)

In 1999 the UK government tasked an independent consortium of researchers to investigate the impacts of GM herbicide tolerant crops on the biodiversity of Britain's farms. At the time it was the largest and most thorough study of its kind in the world; 266 trial sites across England, Scotland and Wales were chosen, which lasted for five years. Four crops were chosen: herbicide tolerant sugar-beet, maize, and spring and summer oilseed rape (OSR / canola). Of the four crops used, only the sugarbeet was tolerant to glyphosate (the other three were all tolerant to glufosinate-ammonium).

The likely impact of glyphosate tolerant sugarbeet included:

- A reduction in weeds and weed seeds, which could have long term impacts on biodiversity as these are an important source of food and shelter for wildlife;
- A reduction in weed populations could have severe long term repercussions on bee and butterfly populations;
- Farmland birds could be similarly affected, as some of these rely heavily upon weed seeds for their survival, especially over the winter months.
- Commenting on the results in 2004, the UK government stated that it would oppose the commercial cultivation of GM HT sugarbeet and spring OSR anywhere in the European Union, if farmers managed the crop the same way as in the FSEs.[28]

GLYPHOSATE IN WATER

"There also is little likelihood under normal use conditions that concentrations in the water would exceed levels that would result in unreasonable adverse effects to fish and other species of aquatic wildlife"[29]

Monsanto, 2003

Non-point source agricultural pollution is considered one of the major threats to surface water quality in rural areas. Non-point source pesticide pollution enters streams and rivers via three main routes: leaching, spray drift and run-off. A number of variables can affect surface run-off, including: the time between the pesticide's application and the first major rainfall, the slope and soil types in the catchment and the physico-chemical properties of the pesticide itself. The risk of spray drift is, unsurprisingly, most acute where fields border surface waters. Pesticides are susceptible to spray drift when solutions are applied by ground spray equipment (e.g. tractors or handheld), but even more so by aerial application. As much as 30% of spray applications can move more than 15m from the intended site. Though the impact of spray drift can be minimized by the use of buffer zones between water bodies and crops, there is no buffer zone specified under South African regulations.

Spray drift is commonly regarded as the worst case scenario for pesticide exposure in aquatic risk assessment. However, in South Africa (as opposed to Europe) there have been very few studies on spray drift compared to run-off.

Currently, glyphosate is on the list of the U.S. national primary drinking water contaminants with a maximum contaminant level goal (MCLG) of 0.7 mg/L. The European Union (EU) limit of any pesticide in drinking water has been set at 0.1 µg/L.[30]

- A study conducted by the US geological survey from 2001 – 2006 detected glyphosate and AMPA in 32% of 608 surface water samples collected. In areas with near continual applications (common in areas with HT crops), glyphosate and AMPA were detected 'in almost every sample'.[31]
- Other studies from the Mississippi river basin in the USA, revealed glyphosate and AMPA detection rates ranged from 60 – 100%. Its concentration in rain was found to be higher than any other high use herbicides in the area.[32]
- In Catalonia, Spain, 140 ground water samples were analyzed from 2007 – 2010. Glyphosate was present above limits of quantification levels in 41% of samples, with the highest recorded sample at 2.5ug/L in one location (25 times the European Unions' maximum level of pesticides permitted in water).[33]
- From 1999 – 2003 the Danish government initiated a pesticide leaching assessment programme, aimed at evaluating the leaching of risk pesticides under field conditions. Glyphosate and AMPA were found to leach from the root zone in average concentrations that exceeded the maximum permitted concentration of pesticides in water (0.1 µg/L).[34]

Glyphosate is highly soluble in water, giving it the capacity to be highly mobile in aquatic systems.[35] There is mounting evidence that, once glyphosate, GBHs and AMPA have entered surface water courses, they can cause considerable damage:

- Western chorus tadpoles exposed to the glyphosate product Roundup WeatherMax at 572 µg/L glyphosate acid equivalents (a.e.) resulted in 80% mortality, which the authors suggested resulted from a unique surfactant formulation. Exposure to WeatherMax or Roundup Original Max at 572 µg/L a.e. also lengthened the larval period for American toads.[36]
- A study published this year revealed that Roundup actually induced morphological changes in tadpoles. The author concluded that to his knowledge 'this is the first study to show that a pesticide can induce morphological changes in a vertebrate.'[37]
- Scientists in Argentina exposed embryos of *Xenopus laevis* (African Clawed Frog) to commercial formulations of GBHs. The embryos exhibited 'highly abnormal with marked alternations in cephalic and neural crest development', which are vital processes in cranial development.[38]
- Rotifer (*Brachionus calyciflorus*) (microscopic aquatic animals) exposed to different concentrations of glyphosate had longer embryonic developmental time, longer durations of juvenile and reproductive periods, shorter average lifespan, a reduced net reproductive rate and reductions in the intrinsic population growth rates.[39]

South Africa's pesticide management policy

In December 2010, the Department of Agriculture, Forestry and Fisheries (DAFF) published the Pesticide management policy for South Africa. The rationale behind the policy was an acknowledgement that current legislation governing pesticides in South Africa, especially the main law: the Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (Act 36 of 1947), is outdated and in need of substantial overhaul.

The policy acknowledges that the current legislation falls short in several key areas, such as environmental monitoring systems and the protection of non-target areas (residential areas or schools, for example). In order to overcome these shortcomings, the policy made a number of recommendations, including: introducing special protection for vulnerable populations; taking into account pesticide exposures from all sources, including food and water; consideration of the cumulative effects of pesticides that act in the same way; and mandating buffer zones for pesticide use.

Though welcoming the policy and the space for dialogue it opened up, experienced health professionals have stated that the policy could and should go further, particularly in respect of protecting water sources. Protecting groundwater sources from pesticide-mixing in field and orchards was cited as an area that is often overlooked, while buffer zones should be instituted to protect groundwater from aerial spraying. Modelling systems to predict groundwater pollution from pesticides in agricultural areas could also be developed. All of these could be achieved through greater collaboration between the DAFF and the Department of Water Affairs (DWA).[40]

MONITORING IMPACTS OF GLYPHOSATE IN THE SOUTH AFRICAN ENVIRONMENT

Under the South African Constitution, everybody has the right to 'an environment that is not harmful to their health or well-being' and 'to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development'.[41]

Very little information exists on the environmental impacts of glyphosate within South Africa, possibly because locally generated environmental and toxicity data is not required for the registration of pesticides.[42] Unpublished research into the impacts of Roundup formulations on seed germination in radish and oats indicate that the herbicide did have an inhibiting effect.[43] This risk is seen as minimal, as in an agricultural setting most of the glyphosate would be intercepted by the plant and soil before coming into direct contact with seed. One of the authors has stressed the need for further study on glyphosate's impact on plant populations, particularly when used to kill alien species in natural vegetation. Because glyphosate is 'broad-spectrum', killing close to every plant it comes into contact with, using it to kill invasive or alien species tends to leave behind bare

patches of earth. These bare patches are likely to be re-colonised by more alien weed species. Thus, glyphosate, despite its low cost, is unsuitable for this task.[44]

In March 2009, reports of the aerial application of glyphosate near a school in Marblehall, Limpopo, enraged parents and members of the general public alike. The public outcry forced the Association of Veterinary and Crop Associations of South Africa (AVCASA) to issue a public statement, condemning the actions in the strongest possible terms.[45]

SANBI's herbicide tolerant (HT) crop environmental monitoring study

Although the Department of Agriculture, Forestry and Fisheries (DAFF) is the principle government department for the regulation of GMOs in South Africa, the Department of Environmental Affairs (DEA) is also mandated to assess the environmental impact of GM crops in South Africa. The South African National Biodiversity Institute (SANBI), established by the National Environmental Biodiversity Act (Act 10 of 2004), is tasked with performing this function.[46]

In 2008, ten years after GM insect resistant maize (variety MON810) was approved for cultivation in South Africa, the South African National Biodiversity Institute (SANBI), together with the Norwegian government, launched a three year study to monitor its environmental impacts.[47] SANBI's Dr Lukeshni Chetty, who managed the MON810 research project, acknowledged that after a decade of cultivation, the study came 'a little late'. With the rapid spread of glyphosate resistant GM crops in South Africa SANBI has sought to establish an environmental monitoring project focusing on glyphosate tolerant crops.

The first stake-holder workshop, to define research parameters, was held in early March 2012 at the University of the Northwest in Potchefstroom. Many of the researchers involved in the MON810 project were present, and will contribute towards the project's design and implementation, which can only be beneficial both in terms of the expertise they will bring and for purposes of consistency and continuity. However, the cooperation of the GENOK biosafety centre is contingent upon funding, which remains precarious. It was also clear from the workshop that industry is vehemently opposed to what it views as more 'onerous' regulation and monitoring of GMOs, and presented a largely united front in their opinion. Unfortunately, in the interim period Dr Chetty, the lead researcher has left SANBI, and the fate of the project remains unclear, though it had been hoped that a workshop attended only by scientific experts (and not industry stakeholders) could be convened as the next step.[48] Theressa Frantz who is the director of Applied Biodiversity Research at SANBI, at the time of writing, said that SANBI was yet to 'have a strategic discussion at executive level' on the best way forward.[49]

Source: http://www.dwaf.gov.za/wfw/Docs/March_April2010Enews.pdf

TESTING FOR GLYPHOSATE IN WATER IN SOUTH AFRICA

Under Section 27 of the Constitution of South Africa, everybody has the right to 'sufficient food and water'. The National Water Act (No.36 of 1998) provides the legal framework for ensuring this noble aim, through the implementation of the National Water Policy. The Act defines the National Government, and therefore the Department of Water Affairs, as the public trustee of the nation's water resources.[50] The Act requires the Minister to establish national monitoring and information systems that monitor, record, assess and disseminate information on water resources.[51]

Glyphosate use in South Africa has increased tremendously in recent years, and not only in agriculture. The Working for Water (WFW) programme of the DWA uses glyphosate formulated herbicides to control aquatic invasive plant species.[52] In spite of this, no South African environmental water quality guideline exists to protect the country's freshwater systems,[53] or indigenous freshwater organisms from pollution by GBHs.[54] There is also no maximum residue level (MRL) for glyphosate in water in South Africa.[55] Experts in the field have also emphasized the importance of measuring the risks from breakdown products, as glyphosate usually breaks down too quickly to be analysed.[56]

In South Africa, a number of studies have illustrated that pesticides are frequently detected in surface waters across a variety of agricultural settings. According to the Council for Industrial and Scientific Research (CSIR), elevated pesticide levels (from agricultural run-off) have been detected in some of the country's major river systems[57], including the Vaal, Limpopo, Crocodile, Olifants, uMgeni and Thukela.[58] Despite these findings, the potential impact of pesticides in South African surface waters has been a low priority, and has generally not been considered in aspects of water resource management.[59]

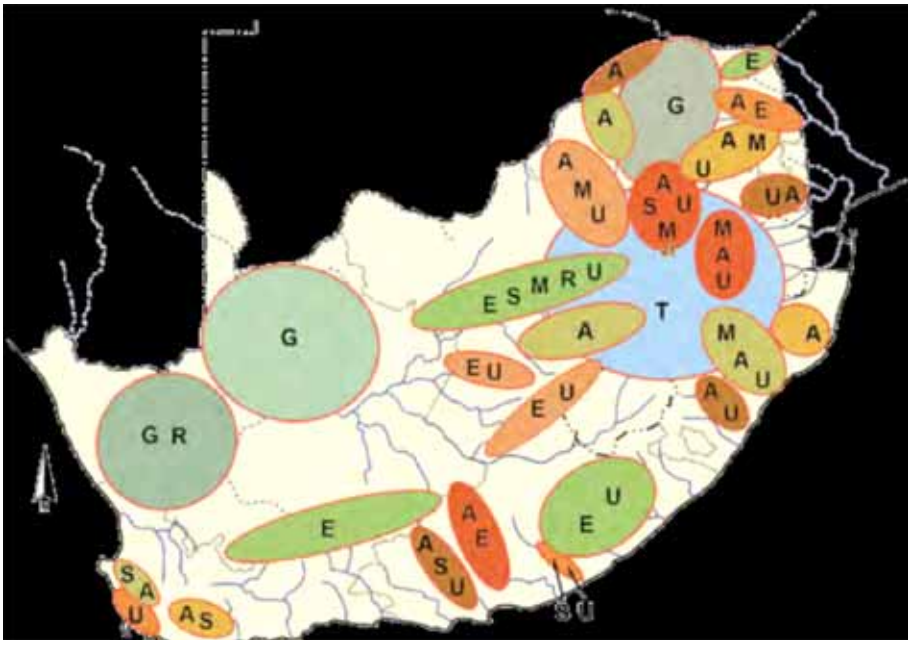
The National Toxicity Monitoring Programme (NTMP) was established in 2002 by the Department of Water Affairs (DWA). A pilot scheme, the third phase in the design of the programme, was undertaken from June 2006 to October 2007. The aim of this phase was to test the design and to establish optimal sampling frequencies for various selected constituents.[60] Water samples were collected from six sites, representing various water-run off scenarios, from urban and industrial, to agricultural. Samples were collected from four sites in Gauteng: the Juksei River at Marlborough, Midrand and the N14; and the Klipriver. Two further sites were selected, at Jagspruit in the North West and Kleinspruit in Mpumalanga. Due to capacity constraints, the programme has so far been unable to expand beyond its pilot phase. While some staff at the DWA have prior experience of working with glyphosate in water, its laboratories currently do not have the equipment to monitor for glyphosate levels in 'any environmental medium.'[61] Currently the NTMP only monitors for atrazine and endosulfan.[62]

Researchers at the CSIR are currently monitoring pesticide levels in water, though the focus is on human health (with water as a pathway) rather than ecosystem health. Glyphosate is not among the pesticides being monitored, as according to the researchers, it is 'extremely difficult to analyse'. Three crop production areas are being monitored: maize (Vals and Renoster Rivers in the Free State), tropical fruit (the Letsitlele River) and Sugar cane (the Lomati River, near Komatipoort). Future studies are planned for deciduous fruit, wheat and grape production in the Western Cape.[63]

Glyphosate MRLs in drinking water

Country / jurisdiction	MRL (micro-gram / litre)
South Africa	n/a
Australia	0.01[64]
European Union	0.1
United States	0.7
World Health Organisation	n/a

Water contamination in South Africa



Source: CSIR (2010). Key: A – Agro-chemicals; E – Excessive Sediment; G – Groundwater contamination; M – Metals (mining & waste disposal); R – Radioactivity; S – Salinity; T – Acidic atmospheric deposits; U – Urban / industrial effluent.

At Rhodes University, research has been taking place into the impact of Roundup formulations on aquatic ecosystems, using Freshwater Shrimp (*Caridina Nilotica*) as a biomarker. Roundup's toxicity was tested in new born (up to 7 days after hatching), juvenile (7-20 days) and adult (over 40 days) Freshwater shrimps. Though newborns were the most sensitive to Roundup formulations, all three age groups exhibited slow and erratic movements. The study concluded that even low levels of Roundup may adversely affect *Caridina Nilotica* health and survival.[65] A study to assess oxidative tissue damage was assessed by determining lipid peroxidation (LPx). The results suggested that Roundup 'exerts toxic effects related to oxidative stress.'[66] (In human's oxidative stress is thought to be involved in the development of many diseases or may exacerbate their symptoms, including cancer, Parkinson's and Alzheimer's disease).[67]

CONCLUSION

Glyphosate is the active ingredient in numerous chemically based herbicides used in South Africa in diverse situations requiring weed control, from household gardens to the management of public facilities and industrial crop and timber plantations. Its market dominance has been entrenched since 1996 with the introduction of crops genetically modified (GM) to tolerate applications of glyphosate. Glyphosate tolerant crops now account for 85% of all GM crops grown world-wide. Glyphosate's popularity has much to do with a pervasive industry marketing campaign that has touted it as a "benign" herbicide with short-lived impacts. However, a large and expanding body of scientific evidence is now showing that glyphosate is far from benign. Glyphosate is a broad-spectrum herbicide that is water soluble. It causes damage to the soil, non-target plants and

wildlife. It has also been documented in numerous locations that glyphosate can find its way into surface water in quantities that exceed legally set safety limits. Where this occurs there is a serious potential for harm to aquatic organisms.

Considering its popularity, as well as the growth in glyphosate tolerant GM crops, the lack of monitoring of the environmental impacts of glyphosate in South Africa is extremely disconcerting. The DAFF's 2010 Pesticide Management policy represents an opportunity to rectify this lack, but 18 months after publication there has been no movement towards practical application of any of its recommendations for improved pesticide management. SANBI, the government body responsible for safeguarding and monitoring impacts to biodiversity, has recognised the need to monitor glyphosate tolerant GM crops. A monitoring programme has been proposed, but severe resource constraints threaten its adequate implementation. Flouting the 'polluter pays' principle, there are no resources available to assess and defend the threats to the collective commons posed by this product while the industry profits substantially.

Rather than waiting for yet more proof of harm, the onus should be on industry to conclusively prove their claims of the environmental safety of glyphosate. Until hard facts are obtained we recommend a moratorium on its continued use.

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