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Observations on the "Study of the effects of the Program for the Eradication of Unlawful Crops by aerial spraying with glyphosate herbicide (PECIG) and of unlawful crops on human health and the environment".

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Bogotá, 11 May 2005.

The document referenced, which was prepared by Keith Solomon, Arturo Anadón Antonio Luiz Cerdeira, Jon Marshall and Luz Helena Sanin ("Solomon *et al*") is an important reference point in Colombia for future work in research on this matter. The authors have attached abundant bibliographical sources to it, with a valuable information on some topics, and wide ranging arguments on the points selected.

The document, prepared under the auspices of CICAD, the Inter-American Drug-Abuse Control Commission, a division of the Organisation of American States (OAS), has deficiencies in its structure, since it lacks the desired order of this type of scientific document. There is a lack of a common theme, which should start from a clear definition of the problems to be validated and of the hypotheses initially proposed, present a procedure to be used (method), results obtained, and a final discussion of those results. These elements are to be found mixed up with each other throughout the text, which makes reading difficult.

The thesis of the study is to show that "(1)... Exposure to glyphosate and its adjuvants, as used in the programmes for the eradication of opium poppy and coca-leaf do not generate adverse, acute or chronic effects on non-target organisms exposed through different routes, and. 2) that such exposure does not produce adverse, acute or chronic effects on non-target organisms expose by different routes...". In this effort, Solomon *et al* essentially appeal to a review of existing literature, and sometimes to experimental testing conducted in laboratory conditions.

Based on the text presented, we make the following observations:

1. **The preface (page 2).**

First, our attention was drawn to the initial arguments of the study. "... The elimination programme for unlawful crops is a matter of intense debate for political, social and other reasons...", and therefore "... this study specifically excludes all social, political and economic aspects, and the final report is based strictly on science and on arguments based on science.. (our emphasis).".

This statement of the authors is highly controversial, for at least three reasons: first, because it excludes the social, human and economic sciences from the environmental analysis; second, because its emphasis falls only on explanations that come from the natural or "hard" sciences, even when it is in reality affecting many aspects other than those considered by them, and third, because it is inevitable that this study, or any other of the same kind made by local researchers, or as in this case, by a group expressly selected from other countries, will be used for political purposes.

Science cannot declare itself neutral in respect to society on the grounds that its method is pure and impartial, when the motivations and results will come to form part of a social debate. Especially so, when dealing with such sensitive subjects in social, economic, political and military terms, and as that of this study, which is at the core of a controversy, with worldwide repercussions, and which are linked to fundamental human rights such as the right to life and a healthy environment for all Colombians.

In relation to the first element mentioned, we must insist that for more than 30 years, the world has recognised that the environmental dimension is precisely a coming-together, of the complex dynamics of society and nature, or ecosystem and culture, and this has been expressed in voluminous literature written both from an ecological point of view and from anthropological, socio-political and economic standpoints (Tamames 1980; UNDP 1990; Angel 1993 a and b); Tyler 1994; Sachs 1996; Angel 1996; Carrizosa, 1999,2003).

Despite their good intentions in demarcating the field of study, which in itself is a legitimate activity, the authors cannot forget the complexity of the matter, especially because it has effects on the methodology and on the conclusions.

It has effects on methodology, because they forgot to include the economic, institutional, political or social effects which herbicidal fumigation has on the fields of farmers (Loss or production of yields in lawful crops, effects on domestic animals, displacements of the population or changes in family relationships among farmers affected, or an intensification of armed conflict in Colombia, to give only five examples).

It has effects on the conclusions, because as can be seen on Page 107 the authors state that "the additional risks associated with the spraying programme are small ..." - when the study did not consider - or if it did, it did so only tangentially - the direct or indirect risks on its systems and neighbouring agro-ecosystems, loss of biodiversity, displacement of the population, or increase in erosion as a consequence of the use of the herbicide.

Second, total confidence in science is also relative. The arguments against glyphosate spraying is abundant in world literature, but they were not sufficiently explored by the authors. This means that science faces problems when it claims to be objective, because it is a human exercise. Here, we should take note of the famous example of a glass half full of water. For some observers it is half full, and for others it is half empty. The so-called scientific objectiveness of the positive sciences is also in doubt.

With regard to the third point, it is sufficient to note that from the day on which the author has published their results, the reactions from civil society and the government were immediate, some in favour and some against, which is undeniable proof of their unquestionable political importance[1].

[1] See press communiqués, letter to the student network abroad, public statements by the Ministry of the Interior and more than 3,500 messages sent to Presidents Bush and Uribe, rejecting the imminent fumigation of the National Parks in Colombia.

2. The focus of the work

The budget has a serious deficiency. It was based on secondary studies to estimate the effects of the herbicide on human health, resorting mostly to those in favour of its thesis, and ignoring those which indicated risks. Further, not only did Solomon *et al* not consult the list of complaints (there are a present more than 8000 in the Ombudsman's Office[2]) produced by a wide range of actors in Colombian society in relation to the environmental effects of fumigations. They would surely have found in large number of data to check.

One piece of work of this kind was done by Luengas (2005) who examined the databases of the Ombudsman's Office and of the Narcotics Bureau (DNE), where they found that 87% of complaints related to damaged vegetation[3], 6.9% to human health, and the rest to animals and bodies of water.

In addition, we consider that the variables selected to estimate the effects of glyphosate on human health (human fertility, in particular time to remain pregnant) is insufficient to evaluate the effect of the herbicide, since:

-these effects are evident over intervals of time which are longer than those considered in that study.

-the effects of chemical compounds of the type used in agriculture are evident on a chromosome scale in the populations exposed, and from an increase in proportion of genetic disease in descendants, but these variables were not considered in the study by Solomon *et al*.

For these reasons, the operators who handle these substances are obliged to use special clothing, and additional safety measures, but this was not the case for the individuals who in one way or another are exposed during aerial spraying of the herbicide over the crops.

With regard to studies which indicate health risks, attention should be paid to that recently made by Maldonado (2003) which presents evidence of genetic lesions in 36% of all women exposed to fumigations with the herbicide on the frontier between Colombia and Ecuador. Other evidence of the same kind should also have been consulted (Nivia 2001; Warren, 2001; Kaczewer 2002)[4].

[2] Personal communication from Ombudsman´s Office April 2005

[3] The result is foreseeable since glyphosate is a herbicide and its first action occurs on the vegetal component.

[4] The toxicity of commercial glyphosate at a concentration of 48% provides a median minimum lethal dose (the amount required to kill half the members of a sample with a single dose) in an experiment with a homogeneous group) by oral administration of 4,900-5,000mg/kg of live weight in female rats and classified as Category IV of toxicity (allocate by the FIFRA), Category III for inhalatory toxicity and Category IV for dermal toxicity. The EPA, following FIFRA criteria and on equal conditions, assigned it to Category II for irritation of the eyes and corneal opacity in rabbits. This last effects, according to the manufacturer, originate from the ethoxylate seboamine used as a surfactant which also has the capacity to

At the same time, Seralini et al, in a recent piece of research on the differential effects of glyphosate and Round-Up, show that it is toxic for human placentas cells JEG3 within 18 hours following exposure in concentrations lower than those used in agriculture, and that this effect increases with increasing concentration and exposure time, or in the presence of Round-Up coadjuvants.

One final point here is that the role of human beings is not only physical. It is also mental. It would have been interesting to explore what psychological effects are produced by aerial fumigation in the perceptions of children, men and women affected by these actions, in which, as is admitted by the expert team, combat aircraft and helicopter gunships take part.

But we will now pass to the general observations on the scientific procedures used:

3. Specification of the problem (pages 22 and 23).

The problem researched is not clearly defined in the text. Traditionally, the definition of research problems is expressed in short paragraphs or in specific questions to be answered (these include the variables to be studied, and reference points in time and space) but in this case they are not specified anywhere. It can be inferred, from the text of page 23 of the document that the object is to "... Evaluate the risk of the use of glyphosate and adjuvants for the control of unlawful crops...". But as there is no clear explanation as to the object of that evaluation, or the conditions of the evaluation, or the procedures used for the same... the document remains ambiguous, as will be demonstrated below.

4. Methodology

The final text does not present any specific chapter on methodology, and readers must look in the body of the text to find the procedures used, and this makes both reading and understanding difficult. Nonetheless, the principal methodological deficiency refers to the overall concept of the study.

For example, in relation to the ecosystem components for which the effects of glyphosate should be analysed (and which forms part of the decision on methodology), the authors have missed their target. If they looked for effects where there were none, or where one could expect minimum risk, this was also due to a deficient definition of the problem to be investigated.

In effect, it is known that herbicides are principally toxic for plants and not for animals (as the authors themselves stated on page 25). In accordance with this position, and the effects to be established, estimated and/or measured, should have been preferentially referred to effects caused by spraying directly on lawful crops or on

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produce gastrointestinal irritation, nausea, vomiting and diarrhea … " Ombudsman´s Office Evaluation Report No. 3010-04 Nook 6 pages 18-31 natural vegetation. We are sure that if the study had been conducted in this manner, the conclusions would have been different, since the spraying of the herbicide affects biodiversity of plants in these areas directly.

One of the principal criticisms of this is related to the fact that, according to results of Solomon *et al*, glyphosate the substance specifically affects only coca leaf crops, and would not affect any other plant species at all. Nonetheless, and as far as we know, the active principle of glyphosate (isopropyl amine) has no species-specific effects, as can be inferred from the results of the work mentioned. Indeed, in the document "Report on matters related to the aerial eradication of unlawful coca-leaf in Colombia" published by the International Narcotics and Law Enforcement Office of the Department of State (September 2002)[5], it is recognised that "glyphosate is an effective, wide-spectrum herbicide, and therefore it can be expected that there is a risk for non-target plants outside the zone of application".

Further, in relation to the soil, it was not an urgent matter to detail the process of adsorption of glyphosate molecules to the clay-mineral complexes of the soil. It was sufficient to make estimates on measurements of the erosion of the resource which, for humid tropical wood and zones in clean crops has been estimated in amounts higher than 25 tonnes/hectare/year. Mosquera (1985) has already stated that erosion in excess of 25 tonnes/hectare/year was considered as severe. Morgan (1996) states that on a deforested surface, stripped to around 35%, erosion had already reached rates as high as 15 tonnes/hectare in humid tropical forest.

It would have been genuinely interesting for Colombia to receive estimates regarding the loss of soil as a direct effect of the removal of vegetation cover caused by spraying with Round-Up, and by the introduction of coca-leaf crops. We are also sure that the work on this point would have been more useful to Colombia.

5 The receiving environment

On page 33 of the report there is some debatable information. The authors say that "... Given that the critical points of diversity are principally associated with the higher altitudes of the Andes, and that coca leaf is mostly grown at the lower altitudes, there is only a certain amount of overlapping (our emphasis) between the areas of production of coca leaf, and the major biodiversity regions...".

As world literature has it, the humid tropical forests, which are the zones in which coca-leaf is grown, are also the hot spots of biodiversity. This means that there is no "overlapping", but on contrary: the zones most sensitive to planetary biodiversity are being fumigated (Sisk *et al*, 1994).

The humid tropical forests are characterised as being systems with most complex structures, stratification and diversity of species in the world. Around 50% of the worlds

[5] http://bogota.usembassy.gov/wwwfepag.pdf

diversity of species of flora described are concentrated in these ecosystems (Gentry, 1993).

Extensive work has been done on biodiversity in Colombia, and it has been produced by a number of different entities: the Ministry of the Environment Parks Unit, Instituto Alexander von Humboldt, the Amazon Research Institute SINCHI, NGOs such as Prosierra, Natura, and a number of universities (Nacional, Javeriana. Andes, Antioquia, Valle and others) which have generated a large amount of information from many different disciplines with regard to biodiversity and pressures upon it, not to mention international institutions such as WWF, Conservation International, or the National Toxic Network. These are entities and works which we suggest should be consulted by the researchers in their studies in the future
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6. Deposits outside the Objective

On page 38, there is some interesting information regarding spraying which goes beyond the objective (coca-leaf plants) and beyond the zones in which coca-leaf is grown. Professor Solomon and his colleagues, citing Payne *et al* (1990) say that the effect is minimal, but that they accept that "... This estimate is based on the visual observations of a relatively small number of crops...", which at the end of the day means that the effect has not been measured.

All in all, the datum presented of 625.7 hectares affected by deposits of glyphosate outside the target area for 2002 is a matter of concern, as is the information provided by the authors on 22 non-target zones which were affected by the herbicide, of a total of 86 sites visited. In other words, 25.6 %. This means that at least one in every four operations in fumigation affected zones neighbouring the coca leaf crops: this is not a "minimum effect”, as suggested by Payne et al. (op. cit.).

This 25.6% calculated by ourselves, based on the information presented in the Solomon report, stands in contrast to the low percentages of surface indicated in the report ("... Between 0.25% and 0.48% of areas for coca leaf production were damaged by the deposits of the spray outside the site...)". It is not known how this information was obtained, since the authors themselves admit that there was no evidence taken on the ground.

Further, Professor Solomon and his colleagues compare these zones with the whole surface area of Colombia, and conclude that they are small, a comparison which does not seem to us to be valid, since by the same reasoning we could say that the approximately 80,000 hectares of coca leaf now under cultivation in the country are also very small it compared with the total area of Colombia (7.1%).

7. The reference framework for the evaluation of risk (pages 39 and following).

The method selected to assess the risks to human health is not properly described. We do not know what the ranges adopted were, nor are we aware of the criterion

adopted to use the scores of 0 to 5. Was it adopted by consensus within the group? What are the equivalents in each case of a score of one, 0.5, or 3, for example[6]?.
In Table 11, it is remarkable that 5 points were awarded (as a maximum effect on human health) to the process of slash-and-burn. We ask, what are the effects to human life of felling a tree and burning it? Have the authors not confused and evaluated a risk affecting the loss of biodiversity, which is indeed "5"? And in harmony with this, how were the recovery scores obtained? Why include the impacts of saying and use of fertilisers if their intensity scores are equal to zero?

Something of the same kind occurs with the ecological risk (Table 12). Here, what is interesting is the low level of scores allocated to the sowing (1) and use of pesticides (2). Since the procedure for awarding these scores was not specified, we believe that there they are underestimated. The sowing of coca leaf, to the extent that a clean crop should generate significant erosion effects in the soils of humid tropical forests, where the slopes and high rainfall carry away large quantities of soil material. The same happens with the use of pesticides. The authors present lists of toxic agricultural chemicals used by the coca growers, which include substances in Categories 1a and 1b, which are highly toxic for non-target species. So, why allocate such low risk intensities?

Mention is made in the conceptual model that the toxicity data for glyphosate are obtained from literature, and that the tests for acute intoxication of animals in laboratory conditions made with the glyphosate-Cosmoflux mixture, but no test protocols were produced. Nor is there a presentation of the way in which the processes of exposure from the food chain and water consumed has been estimated. Thus, and in the same way, there is no mention of the protocols followed in the epidemiological studies, and in toxicity tests in standard organisms (page 42)

The discussion of the effects of POEA, which are the authors admit as being important, are diluted in the text, and are not presented as adjuvants which have toxic effects greater than glyphosate technically should have. This discussion is ignored. There are no mentions of the quantities of POEA used, when the DNE admitted, at least until 2002, that this coadjuvant was part of the mixture used. No mention is made either of the appearance of Dioxian molecules, which are highly carcinogenic in animals, and commonly appear as impurities in the mixture.

8 . In relation to the characterisation of exposure (Chapter 3, pp 44f)

We are not entirely certain that the group of sprayers has the greatest possibility of being exposed to glyphosate, as is stated on page 44, given the safety measures

[6] It should be noted that one of the recommendations of the study of the supposed effects of glyphosate on human health prepared by the Uribe Cuallar toxicology clinic and requested by the US Embassy is "to be able to determine whether there is an increase in the frequency of health problems and illness after aerial spraying with glyphosate and if this supposed increase is related to that exposure, a prospective epidemiological-environmental study needs to be conducted. But this was not possible since the design and execution of this study took place five months after the aerial spraying."

which they take. We believe that the most vulnerable group is that of the coca-leaf producers, who are the “bystanders”.

With regard to the exposure of bystanders (the name given in the study to those were exposed in the field, or in zones close to the crops), the extrapolation of information from bibliography to reality is a matter of concern (pages 46-50).

The authors state that "... It is not common that there are people present in a coca-leaf crop during the application of the pesticide, and it is possible that one person may be in the direct corridor of the spraying, and that he may receive a direct application...", but this is pure speculation. Nobody has counted the number of persons present at the time of fumigation in Colombia, or the way in which they are exposed to the herbicide (naked torsos). No assessment has been made either of the real conditions in which the coca-leaf growers do their work: heat and humidity have an influence on the human metabolism, and may substantially modify the patterns of absorption of the skin through sweat, and through a more open pores in the coca-leaf growers. To this, we should and the conditions of nutrition (which can be assumed to be low in these areas), and of the immune defences of these workers, all of which are unknown variables.

Here, it would be convenient to cite the recommendations made by the Environmental Protection Agency (EPA) in 2002 to the then Secretary of State Colin Powell, in her relation to fumigation in Colombia. "... There is no detailed information at the time of application regarding the history of exposure, or medical documentation of symptoms related to the exposure to glyphosate mixture" (page 17)... "... During spraying operations, it is recommended that complaints should be tracked, and exposure times documented along with the onset of symptoms, in order to be able to evaluate the effects on health, and to reduce or prevent that occurrence" (EPA, 2002). These EPA recommendations were not implemented in the studied by Solomon et al.

For exposure to glyphosate through diet and a drinking water, there are speculations made with data from several parts of the world (using examples from the United States and Denmark), but here again, we cannot presume conditions of equality, since the Colombian coca-leaf growing areas are located in tropical rain forest (with annual rainfall of around 3000 mm, relative humidity of 100%, ambient temperatures of over 28 degrees centigrade, and oxysol-type soils, amongst other factors) in which no doubt the dynamics of chemical molecules are very different to those in temperate zones.

Therefore, it is at least not relevant to describe exposure values to the coca growers by direct spraying, a re-entry or inhalation, estimated any on a basis of a review of literature.

Given the importance of the study, and its undeniable consequences in decision-making, the authors should have considered the possibility of studying the many complaints made by a affected producers (more than 8000 at present), on the files of the DNE and the Ombudsman's Office, and based on that, design a methodology to be established *in vivo*, for the parameters that instead they looked for in literature.

Colombia is perhaps the only country in the world which can offer "science" real testimony of thousands of individuals affected by fumigations, and it is a duty of science to base itself on such testimony in order to verify it or reject it. Anything else is speculation.

Further, as will be seen below, the authors did not describe the "experimental" conditions to justify their statement on Page 50 which says textually "... Exposure due to the consumption of a surface water is considered to be low and infrequent, in areas in which spraying was used for eradication..."

9. Environmental exposure (p. 50ff).

The authors present bibliographical evidence designed to show that concentrations of glyphosate in surface waters "... are relatively small...", but they recognise that this has not been measured in Colombia. They therefore propose a monitoring study to measure concentrations of glyphosate, AMBA and other pesticides in surface waters.
Unfortunately, the writers do not describe the general conditions in which the study was conducted, although they cite individual reports in which there are greater details on temperature, rainfall, and soil characteristics. In the absence of more information, and only in respect of the content of this report by Solomon *et al*, is it possible to ask and answer the following questions (page 54)?

-What were the criteria used to select the five zones (Valle del Cauca,. Boyaca, Sierra Nevada, Putumayo and Nariño) so dissimilar among themselves, not only in terms of geology, and geomorphology, soil, climate and vegetation, but also in relation to the systems of management of their productive units?

-What are the internal soil parameters (morphology of modal profile, texture, hydraulic conductivity, permeability, water table, mineralogy and organic material) used to differentiate the zones selected? Were these parameters characterised?

-What were the external parameters (drainage, gradient) of the soils in the study? What is their taxonomy?

-As of what specific moment after the applications of glyphosate was sampling started?

-What dose of herbicide was used? What type of crops was it applied to?

- What was the area sprayed with because it in relation to vegetation cover in the micro-basins studied?

- Why were microbasins close to the areas selected not used as control areas?

- How close to or far from the fumigated zones were the sample zones? What obstacles were there, or what factors favoured the arrival of glyphosate in surface water?

-What were the criteria used to define sampling frequencies?

-What were the baselines for the comparison in time and space?

These questions are relevant, since the variables mentioned affect the interpretation of the results obtained.

Therefore, it is not appropriate to state that "... There has been little or no contamination of surface water with glyphosate, in any significant concentration, due to the use of glyphosate in agricultural spraying or eradication in Colombia...". This statement, which is in itself a conclusion, cannot be drawn from the study of the five sites, with limited sampling, and as many uncertainties as have been noted here. It goes beyond what can be proved in the field with the stations selected, and it exaggerates the magnitude of data obtained: that is to say, it is not consistent with the methodology employed.

In relation to the effects on the soil (Section 3.1.4.3) the authors present Table 15, in which there appear various data which are not supported in the text. They also accept that "there are no direct measurements available of the concentrations of glyphosate and AMPA on the coca-leaf and opium-poppy crops...". And there indeed they conclude that the recolonisation of plants is quick, and that "no adverse effects in terms of recolonisation all resowling of the crops sprayed has been observed...".

These statements contradict others in the same text, which speak of the "Re-treating " of the coca-leaf crops once or twice a year.

But beyond these effects, the members of IDEA insist that the direct effects of the herbicide on soil should have been looked for more in rates of erosion than in biological persistence. Nonetheless, in this area, literature offers examples which show that glyphosate may persist in the soil for months or indeed years, and that the products due to alteration of it may be more toxic than the original molecule.

10. Characterisation of effects

The document presents a varied sample of articles in favour of and against the effects which glyphosate does or does not cause in mammals and in humans. Almost all of them that showed that there is some link between glyphosate and a negative effect on human health are strongly criticised, and then discarded as invalid evidence. Indeed, there is one footnote (page 58), in which two articles by Post (1999) and Cox (1998) are rejected as being cheap pamphlets, which pretend to have a semblance of scientific publications.

It is curious that almost half the quotations used by the authors to demonstrate the harmlessness of glyphosate referred to Williams (2000) and Williams *et al* (2002,) and these are a researchers whose work has been done with the sponsorship of Monsanto, the company which produces glyphosate.

After each review of a specific subject, the authors draw their conclusions that glyphosate is not toxic in any event, but this is not consistent with the works which are cited (see the second paragraph of page 63). Note that Solomon *et al* mention here POEA as possibly responsible for toxicity in suicides for.

We are nonetheless pleased that the OAS experts admit that "... Exposure in the populations studied was never directly measured, and the use of substitutes is common... That they are open to significant error... The consequences of this supposition may be a high rate of false positive results in the classification of exposure... *The impact of this error may be deeper, and has rarely been quantified. Until the classification of exposure to pesticides has been improved in epidemiological studies, the results of the effects on health are subject to buyers bias in erroneous classification..*." (page 64)

This statement by the authors of the OAS report themselves summarise the key to the debate.

From that point onwards, the authors expound various examples of studies that relate cancer to glyphosate, but following his same line of analytical bias, they rebut those studies in order to conclude that this is not the case, and that also there are no probable neurological effects, or effect on human reproduction.

11. **The effects of glyphosate on non-target environmental organisms (sic) (pages 72 ff).**

As in the previous cases, the authors present evidence on the negative effects of the herbicide, but always accompanied by their comments and criticisms, in order to end up discrediting them for different reasons (unrealistic doses studied, inappropriate methodology used, small number of samples or cases) and rejecting their conclusions. This happens with invertebrates and soil micro organisms, and with land-based invertebrates and invertebrates. Where some negative effect of glyphosate is admitted (for example, on some birds) it is said that these effects are small, or that the organisms affected recover rapidly (p. 7-6). They finally admit certain negative effects on frogs.

It would be advisable for the authors to consider the report which criticised glyphosate in its pure form and the coadjuvants, and commercial products (Round-up) more seriously. Since we consider that it to be of interest, we attach Schedule A, which contains the analysis of the consultant Jeremy Bigwood, contracted by the Ecuadorian government in 2002 in relation to the harmful effects of glyphosate, and a bibliographical list of two hundred and seven references which the same author has compiled on this issue.

Although it is not our intention to make a detailed analysis of the existing bibliography (this work was entrusted to the OAS experts) we transcribe the abstract of a recent study made by Relyea (2005) which describes the deleterious effects of glyphosate on some aquatic species:

> **The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities**
>
> **RICK A. RELYEA** /
>
> Ecological Applications v.15, n.2 1 apr 2005
>
> [More on Roundup | Response to Monsanto's Concerns on this Study by Dr. Relyea 1apr2005]
>
> *Abstract.* Pesticides constitute a major anthropogenic addition to natural communities. In aquatic communities, a great majority of pesticide impacts are determined from single-species experiments conducted under laboratory conditions. Although this is an essential protocol to rapidly identify the direct impacts of pesticides on organisms, it prevents an assessment of direct and indirect pesticide effects on organisms embedded in their natural ecological contexts. In this study, I examined the impact of four globally common pesticides (two insecticides, carbaryl [Sevin] and malathion; two herbicides, glyphosate [Roundup] and 2,4-D) on the biodiversity of aquatic communities containing algae and 25 species of animals.
>
> Species richness was reduced by 15% with Sevin, 30% with malathion, and 22% with Roundup, whereas 2,4-D had no effect. Both insecticides reduced zooplankton diversity by eliminating cladocerans but not copepods (the latter increased in abundance). The insecticides also reduced the diversity and biomass of predatory insects and had an apparent indirect positive effect on several species of tadpoles, but had no effect on snails. The two herbicides had no effects on zooplankton, insect predators, or snails. Moreover, the herbicide 2,4-D had no effect on tadpoles. However, **Roundup completely eliminated two species of tadpoles and nearly exterminated a third species, resulting in a 70% decline in the species richness of tadpoles.** This study represents one of the most extensive experimental investigations of pesticide effects on aquatic communities and offers a comprehensive perspective on the impacts of pesticides when non-target organisms are examined under ecologically relevant conditions.
>
> *Key words: amphibian decline;* Anax junius; Bufo americanus; Daphnia; Dytiscus; *frogs;* Hyla versicolor; Lestes; Pseudacris crucifer; Rana pipiens; Rana sylvatica; Tramea.
>
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Key words: amphibian decline; *Anax junius*; *Bufo americanus*; *Daphnia*; *Dytiscus*; frogs; *Hyla versicolor*; *Lestes*; *Pseudacris crucifer*; *Rana pipiens*; *Rana sylvatica*; *Tramea*.
Manuscript received 27 October 2003; revised 11 June 2004; accepted 2 July 2004; final version received 30 July 2004. Corresponding Editor: J. A. Logan .

The complete text of this article may be obtained in the Journal, and at the internet address indicated. We transcribe it because it is a good example of serious work on the negative effects of glyphosate. Work such as this could also have been used in a review of literature by the authors of the report.

12. The effects of glyphosate and Cosmo flux on mammals.

The authors propose a series of well-designed and controlled experiments on rats for acute or toxicity, in a single dose, and found clinical abnormalities (p. 87) in some cases, and none in others. For acute toxicity due to inhalation at different times (with different results); for acute thermal toxicity (recording of clinical abnormalities). Rabbits were used for skin irritation tests (contrasting results) and eye irritation to us (contrasting results, although it is accepted that the formulation studied is irritating for the skin and eyes of rabbits).

What is worthy of attention is the fact that, based on the tests made on rats, rabbits and guinea-pigs, the authors extrapolate their results and state that "... The risk to humans from the application of glyphosate, or from its presence in the spraying area is considered minimal...". With the data obtained, what they *can* reasonably say is that such effects were or were not present in rabbits, rats and guinea-pigs, but nothing else! It is not even reasonable to extrapolate that information to apply to all mammals (page 100), All wild birds (page 104).

Nonetheless, the authors accept a "mild-to-moderate irritation of the skin and eyes..." Is this or is this not a risk to human health?

13. Synthesis

* Several of the conclusions reached by the authors cannot be extracted from the data presented by them, especially since these are a matter of supposition and not of real field measurement. This is particularly important with regard to human health.

* The OAS experts discarded a number of studies, and did not consult others in the abundant bibliography on the matter, which might have affected their in conclusions.

* The authors concentrated their efforts on looking for effects in the behaviour of ecosystems in which it can be supposed that they are smaller, and did not look for the behaviour of ecosystems in which the effects are direct and easy to study - the destruction of biodiversity, the elimination of lawful crops, and soil erosion.

* Since the study ignores economic and social effects, it is not reasonable that the authors use the word “environmental" at all: they have deliberately excluded the human population, which is the most important element of the environmental dimension. We therefore suggest that the authors change the title of the study.

* Colombia is perhaps the only country in the world in which there are more than 8,000 people who have complained at the different effects of fumigation. It is with them and for them that studies on the harmful effects on health, domestic animals, and lawful crops and ecosystems should have been conducted. The databases in the Ombudsman's Office and the Narcotics Bureau DNE contain abundant information which could be used in such a case. Also, future studies should have the participation of those organisations, not only in the definition and characterisation of environmental impact, but also in the joint search for solutions to this complex problem posed by illegal crops.

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BRIEF SUMMARY OF THE SCIENTIFIC LITERAUTURE RELATED TO THE EFFECTS OF GLYPHOSATE IN WATER BIOTA AND SOILS.
For the Environment Ministry of Ecuador
March 6, 2002
Jeremy Bigwood, Technical Adviser

Background:

The Ecuadorian government has requested the Colombian government to create a security zone of 10 km. along its frontier with Colombian territory to protect Ecuador from the possible ecological damage that could result from the aerial (chemical) spraying for the eradication program conducted by the Colombian government and the United States to eliminate unlawful crops. The request from the Ecuadorian government has come as a result of the publication of press articles, individual accusations, and communities of inhabitants of the frontier zone (and including an accusation in a federal court in the United States) that sustain that Colombian and American aircraft have fumigated in Ecuadorian territory or in areas close to it. Among the reports of the damage caused by the fumigations in Colombia, there are reports on the death of fish and other water life as well as damages to lawful crops, virgin forest and fauna, including - although this has yet to be proved - damage to the human health. Given the fact that many rivers flow from Colombia to Ecuador , and that there are reports of fumigations of bodies of water in Colombia, the Ecuadorian government has expressed its concerns on the possible effects that could be generated for the environment and the Ecuadorian population.

Members of the Ecuadorian government are alarmed that before the fumigations started, neither the Colombian government nor the American government (which supplies the equipment and has an active role in these operations) has investigated the environmental effects of the various formulas that they have been using in the most diverse ecosystems in Colombia. The massive use of unresearched formulas of herbicides, and the continuing substitution of a formula for another, would not be permitted in the United States or any other country in the world. As a result the mass use of this chemical has not been not studied and there is a lack of research, which means that Ecuador could be facing dangers of unknown proportions.

Even though there has not been a study on the formulas currently used in the ecosystems and biota shared in south Colombia and the northern (frontier) region of Ecuador, there is wide range of scientific literature with respect to the toxicity of SOME of the components present in the formulas that the Colombian and American governments declare are being used. These literature could be divided in three sections: 1) the effects on water biota such as rivers; 2) the soil; 3) insects. In this report we are not going to consider the effects in human beings, [39,187,188] since Ecuador is expecting that the Colombian and American governments will abstain from fumigating in the Ecuadorian territory and zones near to the frontier.

It should be clarified that there has been no scientific research in Colombia with respect to the formulas used in the past or those used today. Moreover, we know that there is an intention to change the current formula in a few months and to use another which has not been studied. In the light of this situation, we can only analyze the effects of SOME of the ingredients used today. Also, we must make clear that except for a few studies like one in Nigeria,[128] most of the research produced came from temperate zones such as northern Europe, Canada, and the United States. Even so, these studies show that some of the ingredients of the formulas presently sprayed in Colombia, could cause significant effects on the water life, including fish and amphibians, in the content of the soils and the insects. Unless and until neutral actors perform impartial research on the current formulas (and past and future formulas), we can only conclude that fumigations represent a clear threat to the Ecuadorian environment.

Effects on aquatic systems:

Even though the presence of glyphosate is smaller in water than in the soil, the chemical has been extracted from the soil 12 days (and up to 60 days) after its application.[39,67,68] But formulas like “Roundup” which contains glyphosate and also contains a surfactant- are more dangerous than glyphosate as such in water systems. The effects of Roundup (glyphosate and surfactant) in water biota are so severe, that Monsanto – the company that produces Roundup – prohibits its use on or near water. In Colombia, problems in fish-breeding operations in lakes and ponds have been reported: these are projects developed with the support of GTZ, which were completely destroyed by fumigations of glyphosate formulas. The toxicity of these glyphosate formulas in rivers is not limited to fish, but also includes amphibians, insects, invertebrates (including crustaceans) and without doubt, other species in rivers and bodies of water. [2,4,19,39,205,206,207] One of the most serious problems of the glyphosate formulas used in Colombia is the fact that some if its ingredients are *per se* more toxic to water life than the glyphosate itself. Moreover, the combination used in the fumigations, produces an additive toxicity.[2] Here we should cite the summary of Abdelghani et al: [2]

“ The acute toxicity of three simple and mixed herbicides (2,4D, Garlon-3A, and Roundup) and a chemical additive (Surfactant Syndets) was evaluated using three fresh-water species (channel or catfish , bluegill, and fresh water crab). Among the three herbicides Roundup was the more toxic in catfish and bluegill than Garlon- 3A and 2-4D. The order of toxicity in fish (Roundup, Garlon-3A, 2-4D) was inverted in the bioassays of fresh-water crabs , respectively. For the surfactant Syndets, the CL_{50} values of 1.9 mg/L (bluegill), 2.3mg/L (catfish) and 15.2mg/L (freshwater crab) were noted, indicating that this chemical additive was more toxic than the three herbicides..”[2aα]

Different fish species have different levels of vulnerability to glyphosate (and of course, the other additives)[185] and the quantity of minerals dissolved in the water[205] and the water temperature[205] also play a role in the regulation of its toxicity.

In research conducted in Australia, the Roundup formulas have presented serious toxicity in amphibians. In a study organized in 1995 by the Western Australia Department of Environmental Protection (DEP) directed by Dr. Joseph Bidwell from the Curtin Exotoxicology Program it was concluded that Roundup 360 (another formula of Roundup containing glyphosate and surfactants) could be acutely toxic to adult frogs and tadpoles in the application rates recommended (1.8 to 5.4kg/ha). Roundup 360 was more toxic in frogs and tadpoles than the technical level of only glyphosate. It was assumed that the surfactant of Roundup and not the glyphosate itself, caused the increase of toxicity.[4,19] It should be noted that the mentioned surfactant (POEA) is present in the Roundup used in Colombia.

The toxicity of glyphosate formulas in water biota is well established, and this is the important issue for Ecuador since many of the rivers that rise in Colombia flow south and enter Ecuadorian territory. In the absence of scientific research on -amongst other things - the concentrations and effects of glyphosate formulas in such a variety of ecosystems, the Republic of Ecuador must maintain its cautious and moderate approach and keep requesting the security strip of 10 kms from the frontier within the Republic of Colombia.

Effects on soils:

Soils are formed by thousands of microbes and invertebrate organisms with more complex animal lifestyle. The roots of plants and trees, seeds and a few fungi represent a large proportion of these micro-habitats.

“Microorganisms play an important role in the decomposition of organic matter and the production of humus, the recycling of nutrients and energy and the fixing of elements, the metabolism of soils and the production of components that cause the creation of additives. Many organisms are in symbiotic relation with plants and animals, being used to fix nitrogen in the first case and microbes in the second. They play a substantial part in the nutrition network.

Among the microorganisms present in the soil are bacteria, actinomycetes, fungus, micro-algae, protozoa, nematodes, and other invertebrates (especially arthropods).”[51]

[α] We include information on the surfactant Syndets because, for fumigation in Colombia, there have been many changes of formula, including changes of surfactant It is currently said that one or two additional surfactants are being added to Roundup (which already contains a surfactant). One is called Cosmoflux IND We do not know the exact chemical nature of Cosmoflux, but we hope that it is not the same ingredient as that found in Syndets

The effects of surfactants and other additives used in the spraying formulas have apparently not been studied in soils; nor have the effects of the well known formulas such as “Roundup”. However, glyphosate as a chemical has been studied. Glyphosate has been designed to be applied directly to the leaves of plants, but “even though glyphosate is not directly applied in soils, a significant concentration can reach the soil during an application.”[74] The studies of the effects of glyphosate in soils could be divided into four categories: 1)nematodes (worms of different sizes); 2) the increase of pathogenic fungus; 3) interference in the micorhizal relations between fungi, nutrients and plants; 4)effects on microbes.

Glyphosate has negative effects on nematodes and other worms and invertebrates.[48,156] Research conducted in New Zealand showed that glyphosate had significant negative effects on the growth and survival of typical soil worms.[39,200]

According to several studies published in scientific literature, glyphosate increases the growth of pathogenic fungus. As a result, these fungi remain in an area to expel their own toxins (microtoxins), which are toxic for many other nearby life-forms including mammals. This means, that in this case we are talking about secondary effects of toxicity. One of the genera that tend to increase in presence of glyphosate is the *Fusarium* genus,[47,82,101,102,103,144,157,183,185] which up to September 2002, was going to be used by the United States government as a bioherbicide (micro herbicide) in Colombia in order to eradicate coca plants; but this proposal was rejected by the Andean Committee of Environmental Authorities (CAAAM) and US President Clinton. Species from the genus *Fusarium* are responsible around the world for serious damage to crops, poisoned soils, birth defects in human beings and in one documented case, the death of thousands of people caused by micro toxins, when they consumed contaminated cereal during the last stages of Second World War. [199]

The interference of glyphosate in the micorhizal relations between fungi, nutrients and plants was published recently in 1998. The micorhizal relationship is a symbiotic association between the mycelium (the cell body) of a fungus, especially basidiomycetes (mushroom) with the roots of some plants and trees where the fungus mycelium forms a tight cover that wraps around the small roots or until penetrating the root cells. This relationship provides an exchange of nutrients and water that benefits the plant and the fungus. In research conducted by a Canadian group lead by the scientist M.T. Wan,[183] the negative effects of glyphosate were almost as toxic in the symbiotic fungus *Glomus Intraradices* , in carrot roots as well a as was the well known but forbidden toxic fungicide benomyl (which was the subject of a successful claim made by an Ecuadorian company against the multinational Dupont). Given the fact that many plants cannot grow without the micorhizal relationship, this is a possible effect of the fumigations with glyphosate that we must consider.

Glyphosate has also effects on microbes in soils. Wan et al. working at Texas A&M University, reported “the evolution of CO2 increased due to the increase of glyphosate rates… Glyphosate stimulated significantly the microbial activity measured by the mineralization of carbon and nitrogen." [74,165] Also, it was demonstrated that glyphosate can reduce the ability of certain bacteria to fix nitrogen.[39,201]

To conclude, there is plenty of documentation of the evident effects of glyphosate on biota and on soil ecology from different research studies already well known in other parts of the world; and it is probable that more negative effects will appear while the research on this subject continues.

Effects on beneficial insects:

One of the complaints against the fumigation program with Roundup (plus surfactants) that the government of the Unites States was conducting in order to eliminate opium-poppy crops in Guatemala, was that bee-keeping businesses in areas near to the spraying zone were destroyed.

" Although the fumigation program had a minimum effect on the poppy crops, according to local farmers, the traditional basis of the production in the region was destroyed, particularly tomatoes, and bees."[202,203] As a result of the environmental pressures and others, the fumigation program was suspended and today the opium-poppy crops in Guatemala are controlled manually. Research conducted by the International Organization for Biological Control coincides with the findings reported in Guatemala on bees; also it shows that there are effects on other beneficial insects.

According to these studies, it was demonstrated that the exposure of insects to a commercial formula of Roundup (glyphosate plus surfactants) caused mortality rates higher that 50% in harmless insects, including parasitic wasps, lacewings and ladybugs. The mortality rate was even higher in one species of predator beetles.

Monitoring and chemical analysis:

Even though there are different methodologies for the collection and analysis of SOME of the components of the formulas that are been sprayed in Colombia in fresh water and soils, they all required relatively advanced scientific equipments and trained personnel. Moreover, this would require a system of stations for monitoring along the frontier, especially in the rivers that rise in Colombia.[1,2,3,7,8,16,22,23,25,27,28,30,31,37,54,59,63,67,69,70,73,79,85,86,92,107,108,109,111,124,125,126,127,132,135,136,138,139,165,166,167,171,174,178,180,181,184,185,187] If a system of this nature is to be developed, substantial funds will have to be made available and under the present conditions the proposal seems not to be feasible. But, in the ideal situation in which funding is found for monitoring, aside from the implications of analysis of water and soils, it would be necessary to monitor the following "indicator organisms":

Indicator Organisms

Water plants, such as green algae
Water invertebrates, such as water bugs

Fish, such as catfish
Amphibians, such as frogs
Soil bacteria, nitrogen fixers
Soil invertebrates, such as worms
Soil plants
Birds
Mammals

Summary:

Based on the studies mentioned here, it is very probable that at least some of the ingredients used in the formulas in Colombia cause negative effects on water biota, including fish, amphibians and insects as well as in the content and function of soils. Considering the fact that science has not classified most of the species even in a small percentage of the ecosystems of Colombia or Ecuador, fumigation can easily eliminate a whole new species before we even notice its existence. This fact could certainly threaten Ecuador´s future exploitation of its natural heritage in biota and biodiversity.

Only when overwhelming evidence based on scientific and impartial research by neutral actors that show without a doubt that the massive aerial spraying methods currently used are harmless to our shared ecosystems – a improbable proposition, according to the research conducted – we can conclude that there is a real possibility that the fumigations will produce harmful effects in Ecuadorian territory. With this situation, Ecuador must protect its territory with a security zone of at least 10 kms to guarantee to its people that the potential harmful effects generated by the massive aerial spraying of the chemical herbicides will disperse within Colombian territory.

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