

No Endosulfan-related Health Challenges in Kasaragod?

A Response

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Responding to K M Sreekumar and K D Prathapan's paper "An Evidence-based Inquiry into the Endosulfan Tragedy in Kasaragod, Kerala" (*EPW*, 9 October 2021, pp 45–53), some of the data from the original paper is reanalysed to arrive at different conclusions.

The paper by K M Sreekumar and K D Prathapan, "An Evidence-based Inquiry into the Endosulfan Tragedy in Kasaragod, Kerala" (*EPW*, 9 October 2021, pp 45–53), attempted a substantive review and critique of the relevant literature and creatively identified quantitative data sets to understand the health situation in the endosulfan-exposed areas of Kasaragod district, Kerala.

To summarise the main points that were made in their paper: (i) the authors agreed on the need to ban endosulfan, based on the application of the precautionary principle; (ii) they reported that the prevalence of health concerns attributed to endosulfan exposure (such as physical abnormalities) was not higher in sprayed areas compared to unsprayed areas, according to their analysis of secondary data; (iii) they challenged attributing local diseases and disorders to endosulfan and the compensation for this that has been earmarked by the Kerala government; and finally (iv) they believed that the activists involved in seeking justice for endosulfan-affected communities blew the issue out of proportion, and were the reason for health problems being attributed to endosulfan, and for the chemical being globally labelled as a persistent organic pollutant, thereby preventing further scientific studies in Kasaragod.

They argued (i) using secondary data analysis that the health profile of the sprayed areas in Kasaragod was comparable to other areas; (ii) using the literature that any health problem in the exposed areas could not be attributed to endosulfan because no such problems have been noted in other areas using endosulfan, and because of the chemicals' properties and absence of any contextual

peculiarity; and (iii) that science had not prevailed in the decisions about bans and compensations related to endosulfan, with activists playing a major role in this process. The specific claims made in their paper have been cited under the various sections in the current response to it.

Having carried out a detailed review and critique of their paper, we question the analyses and inferences drawn by Sreekumar and Prathapan (referred to as "the authors"). In the subsequent sections, we present our critique dealing with (i) their interpretation of the literature and standards; (ii) their analysis of secondary data (with our reanalysis of their results); and (iii) their claims related to the role of activists in influencing the decisions on endosulfan, alongside broader reflections on the science and politics of the matter, by framing the perceived conflict an alternative way. Overall, while the authors have provided one way of looking at the data and the science, we demonstrate that the same data and science can be interpreted in another way. Also, the authors emphasised that policies and laws should be based on science, while we discuss how political and legal decisions may also need to reckon with other considerations, such as uncertainty, people's concerns about the uncertainty, and also morality.

Claims Based on Literature Review

The authors reviewed the literature on (i) the characteristics of and standards for endosulfan usage; (ii) studies from across the world on both ingestion-based toxicity and aerial spraying; and (iii) the environmental and epidemiological studies undertaken in Kasaragod before the spraying and after it. Several claims were made by the authors based on their reading of the literature. We challenge some of the main claims. We argue that the findings presented from the literature and the inferences made by the authors do not negate the possibility of harmful exposure or the health effects that were reported from Kasaragod.

The authors stated, "Nowhere in the world has pesticide use at pest-management

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concentrations caused permanent adverse impact on the health of people,” and that “in no case were there human health issues akin to the tragedy in Kasaragod, due to its normal pest-management use.”

The claim that permanent adverse impacts have occurred “nowhere” is extreme. Even if there are no written reports of permanent adverse impacts, it just means that there are no reports of permanent adverse impacts—not that there are no permanent adverse impacts. In addition, these points overlook whether the studies were designed to accurately capture potential effects—given the possibility of confounding, the time taken for many of these health effects to emerge, and the difficulty in measuring and classifying the exposure status and health effects. There is also the varied nature and quality of preventive measures undertaken in those other contexts.

Further, this claim ignores an important aspect of the history of environmental health in which subtle effects of toxins are being uncovered as research methods and detection techniques improve. An example of this is the case of mercury, where our understanding of its toxic effects has moved from “Mad Hatter disease” to the present “micro-mercurialism,” which is about low-dose toxicity leading to several non-specific health effects (Sato 2000). Persistent organic pollutants also accumulate in living organisms and magnify along the food chain. So their levels within organisms can be much higher than in the surrounding environment, as described later (WHO 2022).

The authors ignore the well-documented impacts of corporate and other vested interests on the setting of thresholds and standards for toxic substances—described in the literature as “corporate epidemiology” (Pearce 2008). Meanwhile, observational studies continue to report associations between human health problems and pesticide exposure even at pest-management levels (for example, Chetty-Mhlana et al 2021).

The authors claimed,

This is the first case in the history of medicine in which all the diseases prevalent in an area were adjudged as induced by a single toxic molecule, which was sprayed in that

area 10 years ago, at a concentration far below the NOAEL.

Contrary to this claim, only a specific list of diseases/disorders was identified as potentially caused by endosulfan based on the literature by a team of medical professionals (cited in Pradyumna and Chelaton 2018). Pesticides are known to have multiple effects on the body (Nicolopoulou-Stamati et al 2016). Even with endosulfan, while the Agency for Toxic Substances and Diseases Registry (ATSDR) factsheet suggests primarily neurological effects on humans, it also mentions a range of effects on multiple organs, bones, and kidneys among animals (ATSDR 2015). As already discussed earlier, the no-observed-adverse-effects-level (NOAEL) for a chemical is not written in stone. These levels are subject to the latest available evidence. So, a NOAEL by itself does not guarantee any absence of health effects. It is rather a reflection of what is known about the toxicity of any chemical at that point in time.

The authors stated that

the sexual maturity rate (SMR) scoring of pubic hair, penis and testis, neither was the scoring criteria provided nor were the observers blinded, and thus, the small differences observed indicate the obvious potential for observer bias.

If the observers were not blinded, there is potential for measurement bias. What this means is that measurement bias is one possible explanation for the difference found between the two groups, besides the explanation that there is a real difference. So, just because observers were not blinded, it does not, by itself, imply that the observed difference in health status did not exist in reality.

The authors claimed,

There is no chance of the residue reaching the human system through water. Alpha and beta-endosulfan and endosulfan sulfate adhere to the soil particles and stay bound to the soil, and will come to the aqueous phase in very low quantities (ATSDR 2015). Thus, in majority of the studies, endosulfan was detected in the mud at the base of the water bodies and not in the water. Moreover, its solubility in water is only 0.32 mg/litre.

The claim that there is “no chance” is an extreme and unsubstantiated position. A United States Environmental

Protection Agency (USEPA 2002) document states that

endosulfan is a very persistent chemical which may stay in the environment for lengthy periods of time, particularly in acid media. Due to the persistence of metabolites, vulnerable aquifers below acidic soils could be prone to contamination.

High bioaccumulation potential was also reported. Residues of endosulfan were reported from open well water samples near plantations even a decade after the aerial spraying was stopped (Akhil and Sujatha 2012). Regarding the solubility of endosulfan in water, the reported figure of 0.32 mg/litre is for distilled water, not for surface or groundwater. In addition, water draining in and around the plantation had rich organic content, which may have increased the solubility (Harikumar et al 2014).

It was stated, “In the tropical environment, endosulfan falling on foliage and dry leaves will degrade completely within 7–15 days.”

There are many studies which show that the half-life of endosulfan, both of its isomers and its principal metabolites, is far greater than the stated 7–15 days. The persistent organic pollutants (POPs) review committee reported a combined medium half-life of α and β endosulfan as well as endosulfan sulphate of 28 to 391 days, and the Pesticide Properties Database (PPDB) reports 60 to 800 days (Lewis et al 2016). Further, studies have pointed out that organic-amended experiments resulted in a higher persistence of endosulfan up to 501 days, and that natural environmental factors favour the formation of endosulfan sulphate, which is the principal metabolite with similar toxicity levels as that of endosulfan (Sethunathan et al 2002).

The authors mentioned,

The quantity of diluted spray solution reaching the well water will be too low to cause any poisoning, even if the thatched coconut leaves supplied by the pcc for covering the wells were inadequate or ineffective. ... it is clear that spraying endosulfan two or three times a year in a concentration of 500 ppm–750 ppm is insufficient to build up enough residues in soil, water or air, to cause acute or chronic toxicity.

These are suppositions made by the authors, and once again, no evidence was provided to support it. Monitoring of

waterbodies and other features of the local environment was not done in a systematic and independent way during the years of the spraying. We are not aware of any data on the actual levels and distribution of endosulfan in the local environment during the years of the spraying. The pathways to exposure may also extend to other mechanisms such as direct exposure during spraying operations, and through the food chain. Studies conducted in Kasaragod showed the presence of endosulfan in environmental samples as well as human samples, which indicated exposure or contamination (CSE 2001; Harikumar et al 2014; Odukkathil et al 2018). Several such studies have been listed in a recent paper that compiled the scientific evidence in this case (Sony et al 2022). Finally, if endosulfan can persist in the environment for up to 800 days, the claim made about residues not building up in the environment is contradicted by the existing evidence.

Looking Again at the Secondary Data

Two sources of data were used to understand the prevalence of health problems in Kasaragod. The first set was from the medical camps (screening) conducted to identify victims. The second set was from the Kerala Disability Census 2015 (Sreekumar and Prathapan 2021). From the authors' assessment, the data from medical screening camps is not the most optimal to understand the prevalence of health problems as the camps were not designed or conducted with that objective in mind (Sreekumar and Prathapan 2021). So, we focus on critiquing the analysis and inferences made using the disability census data and offer a reanalysis and reinterpretation. Overall, the main claim made by Sreekumar and Prathapan (2021) was that "the frequency of adverse health outcomes in sprayed and unsprayed villages are comparable," which we challenge.

First, can the disability Census of 2015 in Kerala help us to understand the potential impacts of endosulfan in the affected areas in Kasaragod? Our answer is "maybe" (but not a resounding "yes"), as it is influenced by several factors. For instance, the census was conducted in

2015, whereas the exposure occurred mainly until 2001. Disabled persons suffer a lower life expectancy and higher mortality than would the general population (NHS 2020), and the census data could include the affected population only if the persons with disabilities from the spraying years (before 2001) had survived until the 2015 Census at the same rate as the general population. And also if those households did not disproportionately migrate out of Kasaragod.

In addition to this, there are other possibilities such as the disability census missing subtle disorders. Sreekumar and Prathapan may have made these major assumptions about the data, but these were not stated. Nor was it said how these potential biases were dealt with in the analysis and interpretation. For the moment (in our reanalysis of their results), we will use this same assumption that the disability Census of 2015 reflects the disability concerns before 2001—just to demonstrate that despite these potential biases, the data does not support their claim that the areas designated by them as endosulfan affected do not have a higher prevalence of disability.

The second point to note is that using cross-sectional data from 2015 affects the identification of the exposed group in another important way. Data from the 2015 Census includes people (i) born before endosulfan spraying years (before 1978, or those aged 37 and above as of 2015); (ii) during the endosulfan spraying years (those aged 14 to 37 years in 2015); and (iii) after the endosulfan spraying years (those aged less than 14 years in 2015). So, by designating a sprayed area as exposed, we are also including populations in that area that were born before and after the spraying years. We have a large population that was relatively unexposed compared to the exposed population born during the spraying years.

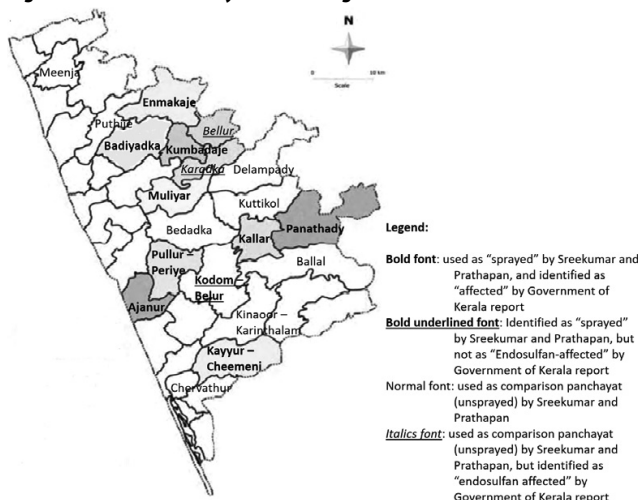
This important consideration of diluting the exposed group (sprayed areas) with people not born during spraying years was not addressed by the authors. Despite this, we demonstrate later in our paper that the prevalence of disabilities was much higher in the sprayed areas, using the same disability census data that was presented by Sreekumar and Prathapan.

Their third major assumption was equating the "sprayed" and "unsprayed" areas to exposed and unexposed populations. They had a list of sprayed and unsprayed wards and panchayats, which were meant to imply exposed and unexposed panchayats, to compare the health status of these areas. This was a critical point and it has not been explicitly explained in their paper. We scrutinise various aspects of this classification of sprayed and unsprayed (exposed and unexposed) areas, and how it significantly affects the results and inferences.

Finally, it is worth noting that there is evidence of endosulfan being smuggled into Kerala even after the ban (Hindu 2010), which further complicates assessing the exposure (correctly identifying an exposed area as exposed and an unexposed area as unexposed). This has also not been taken into account by the authors.

Figure 1 (p 65) shows a map of the sprayed and unsprayed areas in Kasaragod. It reveals two important points—(i) there were 11 panchayats with cashew plantations owned by the Plantation Corporation of Kerala (not 10, as mentioned by the authors), and more importantly, (ii) most of the panchayats chosen by the authors as comparison (unsprayed) are adjacent to panchayats that were sprayed (that is, had plantations). Overall, in their paper, two panchayats that were identified as endosulfan affected by the government report were designated as unsprayed (unexposed), one panchayat indicated as not affected by the government report was designated as sprayed (exposed), and finally, all except one panchayat chosen for comparison (Meenja, unsprayed) were adjacent to sprayed (exposed) panchayats. These points will be used later to interpret the analysis.

There are 38 panchayats in Kasaragod district, of which 10 were identified as "sprayed" by the authors in their paper. Of the remaining 28 panchayats, 10 were selected by them as "unsprayed panchayats" to facilitate comparison. All these 10 comparison panchayats were adjacent to the sprayed panchayats, as can be seen in Figure 1. While it may be argued that neighbouring panchayats are better for comparison because of their proximity to the sprayed panchayats, it would not be appropriate in this situation.

Figure 1: Relevant Panchayats in Kasaragod

Source: Prabakaran (2012) and Sreekumar and Prathapan (2021).

In environmental epidemiology, the goal is to accurately identify exposed and unexposed groups so that a valid comparison can be made and the effect of the exposure can be correctly determined. However, accurate exposure assessments are one of the main technical challenges in environmental epidemiology. So, this simplistic classification of sprayed and unsprayed villages and panchayats is inadequate for comparing exposed and unexposed areas, for reasons such as the dispersion characteristics of pollutants in air and water, and their persistence and accumulation. This is especially important because the spraying was done aerially.

With this simplistic classification of exposed (sprayed) and unexposed (unsprayed) areas, a non-differential exposure misclassification may have occurred. This means, some exposed populations have been wrongly classified as unexposed, and some unexposed populations have been wrongly classified as exposed. The technical implication of such misclassification is a “bias towards the null.” In simple words, the two compared groups have been made similar due to the misclassification when in reality they may not have been. Therefore, a comparison of the two groups will incorrectly reveal “no difference” between them even when there may be a difference.

Based on all these points, the comparisons made between the sprayed and unsprayed panchayats by Sreekumar and Prathapan (2021) do not accurately

represent the exposed and unexposed populations in Kasaragod, respectively. The affected areas were identified by the authors (which they presented in Table 1 (p 66) of their paper) without any reference to a source or a clear basis. Based on this, their classification was highly inadequate from a technical standpoint. Hence, with wrong groups being compared, the comparisons that were made in Tables 4, 5, 6 and 7 of their paper are invalid.

Reanalysing the Secondary Data

Keeping in mind their misclassification of exposed and unexposed areas, we use the same data presented in Sreekumar and Prathapan's article based on the Kerala Disability Census data (Tables 4, 5, 6 and 7 of their paper) to make what we believe are more valid comparisons by using more appropriate comparators.

As accurate individual-level exposure data during the time of spraying (1978–2001) is not available, we will need to be careful about whom we consider exposed and not exposed. For the sake of simplicity, we can consider all wards and panchayats with Plantation Corporation of Kerala plantations as exposed. But it would be inappropriate to consider any “unsprayed” neighbouring wards and panchayats with pck plantations as “not exposed” because we are unsure about how the chemical may have spread to nearby places through air, water, and food. Due to these uncertainties in determining exposure, it would be more valid to compare the so-called sprayed panchayats with areas that are more distant.

One way of doing it is by using the information provided by Sreekumar and Prathapan by taking the Kasaragod average and the Kerala average as comparators to the sprayed (exposed) wards and panchayats. For the moment, we will

assume that sprayed wards and panchayats accurately represent exposed populations (though this is not the case). Table 1 presents the analysis by Sreekumar and Prathapan and under it is our alternative analysis of the same data with more appropriate comparisons.

(i) There are several important observations and inferences to be made based on their analysis and our alternative analysis. The prevalence of disabilities in unsprayed areas (inappropriately identified as unexposed by Sreekumar and Prathapan) is 330 per 10,000 population and the Kasaragod district average is 230.4 per 10,000 population. It is strange that the Kasaragod prevalence is much below the prevalence in the unsprayed panchayats chosen by the authors, while the sprayed panchayats have a prevalence (344 per 10,000 population) comparable to “unsprayed” panchayats. This suggests that there may have been exposure misclassification in their categorisation of exposed and unexposed areas. Overall, the panchayats with plantations and their neighbouring panchayats together have a much higher prevalence of disability compared to the average prevalence in Kasaragod district.

(ii) Based on the 2011 Census, the population of Kasaragod district was 13,07,375. The proportion of people from the sprayed wards and panchayats in Kasaragod was just 6.6% and 21.5%, respectively (based on data provided in Table 1 by the authors). Therefore, comparing the Kasaragod district average with the Kerala state average, as was done by them, is not useful because of a lot of dilution. It can be discarded.

(iii) From our alternative analysis, we see that the sprayed wards (65.3 to 96.7 cases per 10,000 population, p value from z test < 0.0001) and panchayats (82.2 to 113.6 cases per 10,000 population, p value from z test < 0.0001) have a significantly higher prevalence of disability when compared to the average prevalence in Kasaragod district of Kerala state. We recognise that an important reason for the statistically significant p -values is the large sample size of the survey (it was a census), but the differences in proportions reveal the magnitude of the difference.

Table 1: Main Quantitative Results from Sreekumar and Prathapan (2021) and Our Alternative Analysis of the Same Data

From Table 4 of Sreekumar and Prathapan's Paper		From Table 7 of Sreekumar and Prathapan's Paper		From Table 5 of Sreekumar and Prathapan's Paper	
Prevalence in Sprayed Wards (per 10,000 Population) (A)	Prevalence in Unsprayed Wards (per 10,000 Population) (B)	Prevalence in Sprayed Panchayats (per 10,000 Population) (C)	Prevalence in Unsprayed Panchayats* (per 10,000 Population) (D)	Prevalence in Kasaragod District (per 10,000 Population) (E)	Prevalence in Kerala State (per 10,000 Population) (F)
327.9	315.1	344	330	230.4	261.8
Reported as not significant*		Reported as not significant*		Reported as not significant+	
Alternative comparisons and interpretations Pradyumna and Chelaton (2018)					
Comparing (A) versus (E) for difference in proportions (z test)	Comparing (A) versus (F) for difference in proportions (z test)	Comparing (C) versus (E) for difference in proportions (z test)	Comparing (C) versus (F) for difference in proportions (z test)	–	–
327.1 – 230.4 = 96.7 cases per 10,000 population	327.1 – 261.8 = 65.3 cases per 10,000 population	344 – 230.4 = 113.6 cases per 10,000 population	344 – 261.8 = 82.2 cases per 10,000 population	–	–
P-value < 0.0001	P-value < 0.0001	P-value < 0.0001	P-value < 0.0001	–	–
Additional cases of disability in sprayed wards: 833	Additional cases of disability in sprayed wards: 562	Additional cases of disability in sprayed panchayats: 3,192	Additional cases of disability in sprayed panchayats: 2,310	–	–

*p-values based on their analysis should have been 0.07 and 0.006, so it is unclear why they were mentioned as not significant; + p-value was not calculated for this and the explanation is provided in the main text.

(iv) In addition, to demonstrate the additional burden of disabilities in sprayed areas, we calculated the excess number of cases based on the prevalence and population size of those wards and panchayats (in comparison with the average prevalence in Kasaragod and Kerala). It was found to be between 562 and 833 additional cases in the sprayed wards and between 2,310 and 3,192 additional cases in the sprayed panchayats. These are sizeable numbers.

(v) We are not saying that this additional burden is due to endosulfan, but we are saying that the “sprayed” panchayats have a relatively higher burden of cases compared to the average in Kasaragod and Kerala, based on the numbers provided by Sreekumar and Prathapan. Moreover, if we were to remove the data on the sprayed panchayats to calculate the prevalence in the rest of Kasaragod district (all unsprayed areas), the difference in proportions between sprayed and unsprayed areas would be even larger than the large difference that we found while comparing the prevalence in the sprayed areas with the Kasaragod district average.

In the absence of accurate exposure data (which we may never have) and well-documented prospective health data from earlier times, robust epidemiological studies are difficult to conduct. They would have required detailed and technically sound approaches to identify exposed populations (using dispersion modelling and other appropriate methods), surveys covering the family health history of current and recently deceased

and migrated members, an accurate diagnosis of conditions (even of those who have passed away or migrated), and so on. The reasons for the scientific community not undertaking a more detailed study can be explored.

In any case, the studies conducted by the National Institute of Occupational Health (NIOH) adequately argue, using epidemiological principles, that endosulfan was the likely cause for the observed health problems in the exposed areas of Kasaragod district (NIOH 2002). Those studies made better choices in identifying exposed and unexposed populations compared to the classification made by Sreekumar and Prathapan. Raw data from the disability census were not publicly available. It would be good for the authors to state how they accessed the data for their analyses. Access to raw data may have allowed for a more sophisticated analysis.

Claims about Activists' Role

Having presented our argument challenging their claim that exposed areas of Kasaragod district do not suffer disproportionately from health problems, we now turn our attention to the claims made about the role of activists in banning endosulfan and in providing relief measures.

The authors wrote,

One of the reasons that this pesticide molecule was declared as a persistent organic pollutant (POP) by the Persistent Organic Pollutants Review Committee (POPRC) in Stockholm in April 2011 was the campaign by the various stakeholders ... such as the Pesticide Action Network, the Centre for

Science and Environment (CSE) in New Delhi, and Thanal (2009).

No evidence was provided to substantiate this claim. It is important to note that the Stockholm Convention has fixed the criteria against which a chemical is identified and classified as a persistent organic pollutant (POPRC 2019). In addition, members of the POPRC are delegates from the parties to the Stockholm Convention. The POPRC members have the final say in the POPRC process and POPRC recommendations, while NGOs and industry representatives participate as observers. Both the Stockholm Convention and the Rotterdam Convention list endosulfan as a problematic POP based on a comprehensive decision-guiding document and risk assessment prepared by experts from the participating countries, rather than based on campaigns by activists.

They have also said, “National agencies ... charged with finding the truth have taken the easy way out by endorsing the claims of activists, without scientific scrutiny.” Again, a claim without evidence. In addition, while the comprehensive epidemiological study was not undertaken and would have been technically difficult to undertake, the merits of the existing NIOH studies should not be underplayed.

Importantly, focusing only on Thanal and other non-governmental organisations as the main actors in the struggle overlooks the long history of the agitation by communities against the effects of endosulfan pollution and the array of organisations, clubs, and people who have been

involved in such movements. It would be unfair to ignore the role of local doctors, journalists, and activists who were instrumental in identifying the health anomalies. The same can be said of several organisations and collectives such as the Endosulfan Spray Protest Action Committee (ESPAC), Endosulfan Virudha Samara Samithi, Jilla Paristhithi Samithi, Kerala Sasthra Sahithya Parishad, Solidarity Youth Movement, Society for Environmental Education in Kerala (SEEK), Endosulfan Victims' Forum, Endosulfan Victims Support Aid Group (ENVISAG), Punchiri club, and Endosulfan Peeditha Janakeeya Munnani that fought for and continue to fight for succour to the people affected by the disaster (Satheesh 2013).

Given the detailed documentation of these mobilisations organised by local medical practitioners and people living in and around the plantations, the framing adopted by the authors erases a significant period from the mobilisations that brought the issue to the mainstream. The legal battles surrounding the disaster and the intervention of the National Human Rights Commission showed that many interventions from the judiciary had culminated in a ban.

Historically, workers' unions have identified the effects of exposure to heavy metals, and, more recently, pollution-affected communities have documented their toxic exposure (Pradyumna and Narayan 2012; SIPCOT Area Community Environmental Monitors 2004). The role of local people and activists was important in drawing the attention of the pollution control authorities, corporations, and governments. A good example of this was the documentation done by local people and activists in Cuddalore, Tamil Nadu, where the presence of carcinogenic substances was reported (SIPCOT Area Community Environmental Monitors 2004), which was substantiated by a study from the National Environmental Engineering Research Institute (NEERI) (Narayan and Scandrett 2014).

The political response to the Kasaragod tragedy and other such events need not be determined purely by biomedical science. It is important to separate the basis and nature of the political response from the scientific response. In

most cases, compensation is used by those in power for reasons other than just a bioscience-based acknowledgement of harm. This, in turn, is separate from the activists' response which is discussed later.

The court orders are available, and the basis for their actions and judgments are also available. While scientists have particular thresholds that they work with, politicians and the law have other thresholds and considerations. The government too has gone ahead with its own reasoning for the compensation and relief measures. Activists supported the local campaign for the ban, and facilitated the visits of scientists to the area to ensure that the concerns of the people were looked into.

Activists have never campaigned against a thorough and comprehensive epidemiological study. That such a study has not been conducted is a commentary on the resources, politics, and interests that combine to produce scientific research in India. It is not because there was a campaign for banning endosulfan and providing relief to the victims. A similar lethargy to undertake systematic and quality research was also seen in the aftermath of the Bhopal gas tragedy (Pradyumna and Gaithonde 2013).

Handling of Risk and Uncertainty

One of the key aspects of research and evidence on environmental health, especially the toxicity thresholds of individual chemical toxins, is the uncertainty that is inherent in these calculations and derivations. The way the risks emerging out of such uncertainty are distributed is inherent in such a context. Attributing certainty in situations that are inherently uncertain means a false sense of security, given the available data. Under such circumstances, the entire potential risk is faced by communities—the actors with the least power and most precarity in the given situation.

From a strict reading based on the perspective of evidence-based policymaking, the decision of the court and government to award compensation can be seen as being hasty and based on incomplete evidence. At the same time, the decision may be seen as a clear step towards reducing

the potential risk and expressing concern for those who are powerless in this situation. Similarly, the actions of the activists could be interpreted as biased and flawed but they may equally well be interpreted as being clear-headed and just, because their advocacy was in recognition of the inappropriate distribution of potential risk and cost.

While the authors in their paper have rightly pointed out the issue of uncertainty in environmental health, we believe that their interpretation of the “appropriate” role of different actors is based on a rather superficial and simplistic approach to the issues involved. Tesh (1988) has pointed out that focusing purely on the toxicity of individual products pushes the debate into scientific methods, obscuring and distracting from the more fundamental debates on the democratisation of science. Sony et al (2022) have discussed the question of uncertainty and the political nature of its application in the endosulfan case in Kasaragod. The question in our minds is not about either science or politics, but rather about how both science and politics can protect the marginalised.

By coming out clearly in favour of the less powerful, the state has proposed a way forward. While various vested interests may or may not attempt to gain mileage from such bold decisions, the role of the scientific community, in our opinion, is to debate all viewpoints and continue to plod along the path of democratisation.

Relief and Compensation Packages

We have shown using the data from Sreekumar and Prathapan's paper that the sprayed areas in Kasaragod have a much higher prevalence of disabilities. In numbers, it was found to be at least 500 cases more than the expected level for the area. However, we feel numbers are less relevant because even if the numbers were low, they would still be worthy of political and scientific attention.

There was a concern expressed that many unaffected households received compensation for diseases not linked to endosulfan. From an ethical perspective, this is far less problematic compared to missing even one affected person.

Compensation is aimed at ensuring that all affected persons receive justice and not one such person should be missed. By casting the net wide and including a range of conditions, it may be argued that justice was ensured to a large degree (Pradyumna and Chelaton 2018).

In Conclusion

We have explained the issues we have with the conclusions drawn by the authors from the larger literature, and why the disability census data may not be the appropriate data set to demonstrate what they seem to have set out to do. We have also demonstrated that the prevalence of disabilities was higher in sprayed areas of Kasaragod district by using different and more accurate classifications, and that there was a substantial difference in the number of cases in sprayed and unsprayed areas.

We have discussed in detail the problems we have with the assumptions made by the authors about different areas being exposed and unexposed to endosulfan. In effect, we have challenged their main claim that the health effects were comparable between sprayed and unsprayed areas, and the role that endosulfan may have played in this. In addition, we have discussed how the role of activists is critical in situations of environmental injustice and how political and legal processes are not primarily based on campaigns by activists, but other factors. We also said that the absence of evidence of similar health effects in other parts of the world does not rule it in the Kasaragod district, given the uncertainties around NOAELs for chemicals.

The absence of a more robust epidemiological study on the endosulfan tragedy goes in tandem with a general lack of interest (and resources) in public health and research. There is a need for better environmental monitoring, regulation, and public health management systems, while greater attention is paid to health equity and instituting preventive measures. This would help protect a population's health and avoid the need for post-disaster studies and interventions, which are invariably inadequate and unjust (Pradyumna and Chelaton 2018).

Statistics and epidemiological data may or may not be able to answer all the questions relevant to pollution- and toxics-affected communities. Many a time the answer is not simply more statistics, but a better and more just engagement with uncertainty.

[Conflict of Interest: Adithya Pradyumna has been involved with Pesticide Action Network India as a steering committee member in an honorary capacity. He also interned earlier with Thanal, an organisation associated with the struggle for justice for affected communities in Kasaragod. Dileep Kumar has been working with Pesticide Action Network India since 2013, involved in research, documentation, and policy works. Silpa Satheesh studied the political ecology of the endosulfan disaster in Kasaragod from 2011–13 for her MPhil thesis at the Centre for Development Studies, Thiruvananthapuram. She has also worked briefly with Thanal in 2020 in the capacity of Assistant Director of Research. Jayakumar Chelaton is a founder member of Thanal and Pesticide Action Network India. Rakhal Gaitonde has been involved with supporting several pollution- and toxic-affected communities.]

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