Content Analysis of Scientific Communication as an Important Uncertainty Factors in Non - Use of Chemicals

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Abstract

This paper arose from a participatory action research project identify and assess the perceptions of farmers and rural workers of the methods of use and health risks of chemicals in the production of oranges, based on scientific information provided by journals and advertisements. Content analytical techniques were applied to publications retrieved in an Internet search using the keywords Paraquat, Glyphosphate and Chlorpyrifos, which was undertaken between November 2019 and June 1, 2020. The data collection involved a total of 839,673 articles from general interest websites and 18 academic articles that were found on the Internet. As well, in-depth interviews were carried out with 15 farmers who are chemical users to assess their perceptions of the media and attempts to discourage chemical use. The findings suggest that there is uncertainty in the change of behaviour of those participants in ceasing to use agricultural chemicals with implications for cessation behaviour of farmers in Thailand. Such uncertainty is seen to arise mainly from unclear communication and inconsistencies in the communication content of scientific information. This includes the use of rhetoric in storytelling and research findings that causes conflict in the science communication thus causing of misunderstandings. The research results of scientists who were collecting data from farmers should convey their information findings to the farmers in a form that they can easily understand. However, our analysis found that the research results are often only published on academic websites and in the departmental website and the informtion only becomes available to farmers once it becomes news in the popular press and online media by which time it has become repackaged as politically, economically and socially relevant issues. Farmers do not understand the scientific arguments that support the use of certain chemicals or the danger of overdose or incorrect use of these substances. Some people may accept what scientists say without understanding the meaning therefore there is uncertainty about the effects and dangers of these chemicals.

Keywords: Science Communication, Persuasive, Farmer, Chemical, Uncertainty

Introduction

There is a significant discrepancy in scientific and technological development between countries with low income levels and GDP and the developed countries. This has been described an a deficit model of income disparity in national economies, education budgets, and income levels in ethnic and other minority groups (Durant, 2010; Nisbet et al., 2002; Nisbet & Scheufele, 2009; Leshner, 2003; Miller, 1983). These discrepancies are especially manifested in rural areas and amongst small holdings farmers and agriculutral workers. This demographic is at significant risk of health problems owing to their frequent and long-term use of agricultural chemicals for weed and pest control, often mishandled without proper protective equipment and safe handling methods due to poor information availability and education in these matters. However, use of these chemical has been widely encouraged in scientific publications and product advertisements. The viewpoint usually presented and promulgated by academicians and scientists on promotional visits to these people, including the provision of and availability of samples presented to local farmers, has almost inevitably been to promote and encourage the use of these chemicals to solve agricultural problems with pests and weeds, and to be beneficial for plant growth. Farmers themselves are often agents for these products, lending local credibility to their use while profiting from sales. According to

Chatiket (2005) more often than not these agricultural chemical products have been promoted as beneficial without any consideration the side effects and potential risks and possible harm to personal health.

Scientific communication refers to the publication and dissemination of scientific information gained from field tests or experiments carried out in the laboratory. This apparent scientific basis for promoting their use helps to construct credibility and trust in the efficacy and, by implication, safety in the use of chemicals. However, the side-effects of these chemicals are seldom mentioned.

The recipients of this scientific information often have low educational levels, not uncommon in rural areas amongst farmers and rural workers, and they see science and technology as having a high level of credibility and trustworthines in providing answers to agricultural problems. The implications found in 96.9% of the published scientific research analysed was that research errors were never mentioned and only an apology may be given in the research paper at the last paragraph, for example *"Most of the data presented to the editor can not be verified"* (Hesselmann & Reinhart, 2019) scientists usually present their work in a very positive light and negative aspects may not be mentioned. (Daston, 2004; Keränen, 2007; Durant, 2010; Besley, 2010; Kurath & Gisler, 2009; Leshner, 2003; Rogers-Hayden & Pidgeon, 2007)

Palmer & Schibeci (2014); Kurath & Gisler (2009); Miller (1983) considered that scientists must communicate not only to other scientists, but also with the public in a language undertandable by the layman. Not communicating effective with affected communities will potentially result in negative outcomes for those community members, both financially and for their health.

An important issue relating to chemical use that has been widely discussed in Thailand and around the world, is the prospect of banning of Paraquat, Glyphosate and Qaupyrifos, three important agricultural chemicals in widespread to control weed and insect pests. From the perspective of marketing communication, people are confused about the value of these chemical and are divided into two opposing camps, those using chemical and those not using chemical. They do not understand the arguments about environmental impacts and health impacts on people and are often unsure of the safety of these chemicals, and even unaware of the health implications.

Our research analysed the scientific messages found in the media where there is limited time and space for the distribution of information, such as in paid advertisements in which emotive or 'catchy' slogans used to evoke a positive, but fundamentally uninformed response in the readers. The conflict between social determinism and social practice occurs when people behave in ways that may be different from what is expected. These differences may have an impact on their thinking and lifestyle choices. This is known as miscommunication which is very problematic when that communication purports to be truthfully, reliable and informative on a topic where creating an understanding of the scientific issues through the participatory method is important, even imperative.

The geographical area in which our action research was carried out is the lower north of Thailand, in a local area where chemicals are routinely used on orange farms. However, being bound by agreements with the Ethics Committee of the University, the specific geographical locations and participants cannot be identified, especially as the intervention variable conflicts with law enforcement and contradicts the various ministry authorities.

Our study does confirm a shift in the uncertainty found in scientific communications. The framework of scientific outcomes and issues distributed through online media do impact the thinking of people, often in a poorly informed way. Given the prominence of the three agricultural chemicals glyphosate, Paraquat and chlorpyrifos in agriulture, scientific communications and product advertisement for and about these chemicals, published or referenced on the Internet during 2019 and 2020, were selected for content analysis in our study.

Literature Review

The concept of science communication arises from Popper (1959) and was advanced by Thomas Khun, ultimately developing into the concept of the Paradigm Shift (Popper, 1959; Lakatos & Musgrave, 1970; Ishido et al., 2017). Communication science has been seen as controversial and has uncertainties (Lee & Scheufele, 2006; Dudo et al., 2011). Miller (1983) found that ideas that may be statistically significant on sample-sized tests may be relevant to that particular sample, but they may not necessarily be relevant when applied to the population as a whole. It may be said that science communication must be aware that a small sample size and the apparent concise nature of sample-based information may be irrelevant to the broader community, a problematic situation considered under the heading of scientific ethics (Keohane et al., 2014). The problems addressed in communication science, and scientific ethics, arise where the media announces uncertain scientific research results without full disclosure of those uncertainties. (Brechmann et al., 2009; Retzbach & Maier, 2015). Further, the media often, necessarilly, simplifies scientific information thereby presenting a new and often less than correct message (Ebeling, 2008). Some scientific information or research findings may be negative and even shocking or frightening, potentially cause the general public to panic, thereby creating a situation that is more than just a matter of awareness (Stocking, 2010). Scientific information published in the media may be presented in the form of documentaries, or news items, or as product advertising (Mende et al., 2012). In the United States of America (National Science Board, 2012), the population in general has received a sufficient level of education that is creative and largely scientifically based and, therefore most people are inclined to believe information if it is perceived to be scientific, thus this information exerts a significant influence on the behaviour of people. The popular media, by its very nature, promulgates information by broadcasting to a wide audience, thereby providing widespread access to and consumption of media content (Bandura, 2001; Bandura, 2009; Shrum, 2009; Price & Tewksbury, 1997; Shrum, 1995; Nabi & Sullivan, 2001).

When scientific information is classified into some particular categories, especially agricultural science, the health sciences and environmental science, that information may have come from laboratory experiments and may not necessarily have been tested in the community or in the field of that area of science, for example, in agricultural field tests. A further, not insignificant problem, is where those who are responsible for public communications, such as journalists and advertising media creators, either have little interest in publishing the information, or have limitations concerning space and time and production costs, so the marketing of products is often intended to promote the product to enable the organization to generate a profit without attention to full disclosure. The media information in these cases is therfore often limited and may be reduced to a mere advertising slogan. Marketing media is therefore mechanical and may be limited to presenting the product in a positive light. Any negative aspects may not be mentioned at all. Simply put, persuasive communication manipulates agricultural, environmental and marketing information, often unintentionally.

The sender (media) sets the direction of the policy content with persuasive messages, pictures, sound and an outgoing and enthusiastic attitude that is intended to change the behaviour of the recipient, for instance, Hovland Janis and Kelly (Hovland et al., 1953) found that influencers (these may be experts, prominent leaders or celebrities) who can enhance the sender's credibility and encourage the acceptance of the message by recipients because of their verbal and non-verbal presentation. Change agents are influencers who can change people's opinions. Individual ideas are collected into groups for making decisions following that of the opinion leader. Gruning (1992) as cited in van Riel & Fombrun (2007, p. 33) described effective advertising and propaganda as the telling of a partial truth using

technically effective communication. However, Tabellion & Esch (2019) and Zhang et al. (2017) explained that the influencer is a new technical term in the marketing field. Influencers are attitude and behaviour change agents on digital media. Influencers frequently live stream online to tell of their daily lifestyle and opinions with both positive and negative aspects of their experience. Receivers are followers and the number of followers is taken as an indicative statistic to adjudge the marketing persuasiveness of the communication and confirming that that person is popular in the media. In the particular area of agricultural and environmental topics, however, influencers have access to local rural communities through local media and television broadcasts and are able to represent themselves as members of the community who understand and work on solving people's problems. Opinion leaders who have been elected are influencers who gather people in a community public area for discussion and show symbolic communication such as hand-wave, body language and so on.

However, whether they are opinion leaders or influencers, they rely on persuasive communication through message appeals, such as fear messages, humorous messages, emotional appeals and sympathy, presentations. The art of rhetoric shows familiar relationships, similarities, and the sharing of feelings with each other until it leads to empathy for each other or sympathy, then each person will express similar experiences. Personal media is not effective sometimes, but it may influence more than individual decisions. Loman, Jeren, Muller, Babarca, Gruth, Arnould, Barnren Rick (Loman et al., 2018, p. 81) found that the use of language communication to persuade students to reduce alcohol consumption and the students used printed materials such as posters, the media can manage and evaluate the effects of drinking alcohol on health, but does not affect the choice of types of alcoholic beverages. But convincing oneself (Self-Persuasion) has a greater effect on decision making than being persuaded by personal media. And using self-persuasion and health management media is more effective than any other media.

Methodology

This study used the qualitative method to collect data from websites using the words Paraquat, glyphosate and quapyriphos occurring during the period from November 2019 to 1st June 2020. During this period 839,673 articles from general interest websites and the Academic database on the Thai Citation Index (TCI). In all, 18 academic articles were found. The researcher also interviewed 15 farmers in the selected community of citrus growers, particular producing oranges. This area was chosen as there has been some movement to stop the use of chemicals on their farms. The articles selected from the Internet were then subjected to content analysis to identify and categorize the published scientific information on the use of the three subject chemicals in agriculture, and their impact on the environment and in the health sciences field. The criteria of evaluation are in a MAX-MIN Concept which covers 5 points defined as:

5 means most of the details involve agriculture or environmental use or the health sciences.

4 means almost all of the details involve agriculture, the environment or the health sciences.

3 means an average of the details involves agriculture, the environment or the health sciences.

2 means less of the details involve agriculture, the environment or the health sciences.

1 means that none of the details involves agriculture or the environment or the health sciences.

The scores are calculated in an equation of MAX-MIN concept as defined as follows:

1.00 - 1.80 means the media represents the contents of agriculture the environment or the health sciences at the smallest level.

1.81 – 2.61 means the media represents the contents of agriculture or the environment or health sciences at a small level.

2.62 – 3.41 means the media represents the contents of agriculture or environment or health sciences at an average level.

3.42 – 4.21 means the media represents the contents of agriculture or the environment or health sciences to a greater degree.

4.22 – 5.00 means the media represent to the contents of agriculture or environment or health science to the greatest degree.

The mass media sites were categorised as above according to the extent to which they publish information on agriculture, the environment and marketing and also according to scientific theory. The participants of the study are asked if these websites can influence their thinking. Five people who had stopped using these chemicals on their lands were interviewed to assess the impact of information in the media on their decision to stop using chemicals.

Results

The results were calculated according to an analysis of the contents of research in the laboratory and the field. There are 18 articles on TCI database and 839,673 articles from general websites. These articles were found online using searches with Paraquat, Chropyrifos and Glyphosate as keywords.

1. A Short History of these Chemicals

In the late 19th Century, Lassaigne and Philippe (Lassaigne & Philippe, 1854 as cited in Ihde, 1972) isolate phosphorus as an organic substance. Later, the compound sulfuric acid was found and extensively used in pesticides, cleaning agents and in soaps. It was also found in the nervous system. In 1932, Willy and G. von Krueger, chemists, explained that Cholinergic agents are compounds which can inhibit the respiratory a nerve functions of living tissues. IG Farben became the biggest chemical company in the world in 1925. The German, Nazi Party invested in the company and the chemical industry to produce glyphosate and organophosphates, even though they knew these chemicals to be dangerous to human and animal health. In the marketing, warning labels were placed on chemical containers to indicate the danger in using these products.

Paraquat or N,N′-dimethyl-4,4′-bipyridinium dichloride (scientific name), also known as Methyl Viologen, is an organic compound with the chemical formula [(C6H7N)2]Cl2. Paraquat may be in the form of a salt with chloride or other anions; quantities of the substance are sometimes expressed by cation mass alone (Paraquat cation, Paraquat ion). The name is derived from the para positions of the quaternary nitrogens. Paraquat was synthesized in 1882 for use as a herbicide. In 1961 the IOC Company, now Cingenta, marketed it under the Grammoxone trademark, it became well known worldwide. In 1965, the U.S. EPA Company registered Chropyriphos as a pesticide for use in the soil and on the leaves of plants until the Dow Agro Science Company began to use it in other ways as well. Organophosphate (OP) can stop Cholinesterase Enzyme; BuChE & AChE and destroy Acetylcholine in the nervous system of human and animals.

2. Science Communication Presents Academic Language and Persuasive Communication

Strategic marketing communication is a tool that could be used by science and technology in their strategy to develop ways to change people's thinking and activities and solve the problems which many people face. Some information is not honestly given, thus these chemical manufacturers are not necessarily open or transparent as the chemicals that they manufacture could be hazardous to human and animal health, thus openness and transparency

are compromised. In this study, an Internet search was carried out on the way Paraquat, Chropyriphos and Glyphosate are presented. Around 86,600 advertisements created from scientific information using a beautiful image of agriculture products and the guarantee or mark, an ISO standard mark or safety guarantee by the various manufacturers and other organizations.

Table 1 Analysis of Rhetorical Contents of Sampled Publications

Rhetoric Form	Science Content Categories ($\bar{x}$)			
	Agriculture	Environment	Health Science	Marketing
1. Academic Tone/ Style	(0.8) smallest	(0.6) smallest	(3.48) greater	(1.88) small
2. Opinion Leader/ Academician	(2.20) small	(3.8) greater	(3.89) greater	(0.00) smallest
3. Maintain Agriculture Problems	(4.12) greatest	(1.48) small	(0.42) smallest	(4.48) greatest
4. Improved Productivity	(4.89) greatest	(0.00) smallest	(0.00) smallest	(4.88) greatest
5. Confirmation by Farmers	(4.98) greatest	(0.00) smallest	(0.00) smallest	(4.92) greatest
6. Fear Messages	(0.00) smallest	(4.97) greatest	(4.90) greatest	(1.95) small
7. Humor/ Amusement	(3.58) great	(0.00) smallest	(0.00) smallest	(3.88) great
8. Reality of Life Documentary	(4.68) greatest	(4.18) greater	(4.29) greater	(4.12) greater
9. Prevention Measurement	(4.11) greater	(4.13) greater	(4.93) greatest	(0.00) smallest
10. Legal Language	(2.87) average	(4.66) greatest	(4.23) greatest	(1.83) small

* see the explanation of the meaning of the numbers in the upper part of Methodology.

Table 1 shows the proportion of contents that use language that can be described as being in the fields of agricultural science, health science, environmental science or marketing. These are categorised as indicating the advantageous aspects of various chemicals, or indicating the disadvantages of using those chemicals, applying different rhetorical styles such as using formal language and technical terms, especially in health sciences field. Environmental science, agricultural science and marketing do not generally use more technical terms as their intent is to persuade all audiences and appeal to their emotions and shared experiences, elicit a sympathetic response by implying the product being a remedy to reduce suffering. Some of the contents of the publications referred to research experiments and projects that discovered innovative methods and practices for farmers and the data had been confirmed by academicians or scientists or used legal language to confirm the beneficial environmental and health impacts that were confirmed by worldwide standards and were controlled by laws. This gave the published data a confirmed formality and correctness.

To analyse and synthesise the rhetoric used by these persuasive communications, they were divided into 3 kinds of techniques and purposes in each field.

2.1 Techniques Applied to Targeted Agriculture Science and Marketing Communications

Publications in the fields of marketing and agriculture communicate through change agents or influencers who share their successful farming experiences in the use of chemical products. Reinforcement techniques use rewards and polite engagement, for example, use words of sympathy for suffering farmers to create positive relationships and describe experience that encourage farmers to purchase those chemical products from sellers.

Influencers present informal language and proudly talk of shared experiences while demonstrating the process of agricultural production enhanced by the use of those products. The sellers are acting as advisors who respond positively and informatively to all target audiences, responding to questions such as What kind of chemicals do I need? How do I use those chemicals? How much do they cost, compared to other brands? How much do I need to use? Language such as ‘Thank you for joining us, we welcome your questions.’, ‘We are here to help

and assist you.', 'Please place your orders early to ensure timely delivery.', 'Please follow the advice of academics, scientists and distributors in you area'.

2.2 Techniques Applied to the Environmental Sciences

Communication relating to the environmental sciences often involves consideration of issues such as water resources, ground and water contamination with chemicals, the impact of chemicals on the environment generally. The environmental communication model developed in this research project helps to show how many people are aware of the environmental harm caused by the use of agricultural chemicals. In environmental videos, for example, the mise-en-scene includes melancholic music and dark, low angle shots showing dirty water and storage tanks leaking their contents into the environment, causing environmental contamination. A narrative is developed through video images or stills showing the progression of contamination from natural or even pristine beginnings to the current level of contamination and damage. Such videos present the message of the need for raising awareness of human interaction with nature to protect the environment and 'Save the Earth'.

2.3 Techniques Applied to the Communication Sciences

Audio-visual communication regarding public health presents the work situation of farmers, characterising them as simple folk, wearing simple and perhaps traditional clothing, dark-skinned because of log exposure to the sun while working their fields. They shown in these videos as being hard-working, often working bare-foot in the rice paddies and fields and orchards. These people are susceptable to illness from parasites commonly foud in the soil and in water, and are subject to to injuries that allow parasitical infection.

The communication techniques in these presentations include narrations in simple, local languages which is related to their current lifestyle issues. The media makers take pictures or videos which accompany their words which are spoken by professional narrators mixed with evocative music. A technique applied is to prerecord interviews or vox-pop with people who may be having voice problems due to illness. During the interview, the cameraman may focus on the interviewee's face, eyes or hands so that the rigors of their work may be clearly seen by viewers. Such photographic techniques may be used to indicate the health problems of people working in environments where agricultural chemicals are used. In other words, the often painful inability to live normally or to do normal activities, with empathetic images relayed on the feeling of closeness to the family of the worker with significant debt problems. While the video contents have shown rural people, they have not included people from the general popultion suffering health problems, nor have the videos addressed the exposure to chemical aerosols that will affect the health of people in nearby areas. Similarly, chemical residues in agricultural products accumulate in the body ultimately resulting in chronic diseases requiring a complement of doctors and health organizations in cooperation with health volunteers in the community.

Discussion of Research Findings

The results of media effect on farmers' usage chemical behavior in rural areas contributed from persuasive scientific communication in 3 branches; agriculture, environment and health science. The outcome of research evidence used the quality research technics confirmed with interviewed 15 farmers in a community who were affected by the communication. It was found that there were two aspects of science communication results, which were positive and negative, which were the factors affecting the communications, causing farmers uncertainty about the termination of chemical use.

1. The effectiveness of positive communication confound from the government officers who visited into fields and providing farmers with information on how to deal with massive crop disease and productivity demands through the use of chemicals – not just herbicides but also numbers of other chemicals including propaganda advertisement (van Riel & Fombrun, 2007, p. 33; and Loman et al., 2018, p. 81) via a trustworthiness personal media for example head of farmer and farmers member clubs who perceived message from government officers or academicians and selling the products to them. The rural people are in trouble of economic inequality and poverty due to the level of education does not meet the needs of the labor market both in the manufacturing and other fields when the economy is in trouble, they will lose their job and become unemployed. Normally people are seeking for a new land because of weather and limited arable land so poor people always borrowing money to invest and renting land for cultivation in a limitation. Moreover, government policy moves forward to be "Thai cuisine in the Kitchen World" resulting in big agricultural plant and huge distribution. Especially, a contract with the country parties encompassing farming policy agreement, requirements regarding the chemicals used in plantations and farms, covering not only Paraquat, Glyphosate and Chropyrifos, to heal the toxic effects on people. Nevertheless, advertisements impacting consumers demand beautiful fresh fruits and vegetables, showing crops that can generate more revenue, economic drivers that promote stable income, reduce the cost of farming and sustaining the costs of education, living expenses and living in a modern way until the small values of chemical use in society practised.

2. Effectiveness positive aspects of science communication of health in providing knowledge to protect themselves from chemicals. Modernization of medical technology and the allocation of primary health care for illness can heal people's health problems. From the experience, even without using chemicals, there are health problems for other causes death as it remarked in religious truths teaching.

3. Effectiveness negative aspects of science communication environment has resulted in the perception that it is confronted with climate change, but do not know how to handle problems that are possible in reality. Also, Thailand has a climate change management policy in line with many countries with no measures or measures are gained chemical tax payment policy to compensate for environmental impact.

Conclusion and Discussion

Over a year, scientists have an experimental to solve human problems by extract natural substances and compound them to make chemicals, such as pesticides. But living things can mutate and resist chemicals. Therefore, in a period, the results used for managing and solving problems that are being communicated regarding further developments and spreading information through the media, create beliefs that change attitudes and become habitual communicative behaviors until they become values, a way of life and culture until the research is to study the chemical known from the literature is that the effect of gradually began to live all the communication science suggestion Retzbach & Maier (2015) shows the following information that can be discussed.

1. Science research and experiment results must show the impact that may be causing the error or uncertainty in the marketing data communications science.

2. Health and environmental impact assessment and news or media should be reported deep information from some part of research to the public, it may be affected society, confusion and uncertainty of some of the truthful scientific implications and become a huge spiral in society. Over time, the spiral disappears from fear, resistance becomes acceptance and change, which takes time and access to people at all levels in all areas, both through

community leaders and through mass communication. At the same time, it is important to consider that communication in social networks plays a vital role at the individual level.

3. Search by word or phrase and the same keywords in the digital database generated a spiral of silence which the issue will return to a big public agenda. For example, the big spiral of the issue to ban Paraquat, Glyphosate and Chropyrifos, are not in use so the laws not acted a point to abolish the use of chemicals. Farmers have a dilemma and have to seek information to address the problem themselves in finding chemical substitutes which this problem does not go back to solve the original cause of environmental problems.

4. Currently, farmers use communication to get to know each other in handling agricultural issues such as the use of antibiotics in both powder and liquid, which is sold through pharmacists may be required by law rather, it is sold directly to the manufacturer or from a dealer. Also, anti-inflammatory drugs are sold as a process of unknown origin and through online ordering, the health effects of which have not been researched nor proven. Therefore, equality under law becomes a doubtful concept.

5. Negative of science message on the media has the power to determine the direction and impact of information will occur in conflict relationships and consequently, farmers are not clear in practice. The reality faced by farmers therefore truly affects the attitudes and behavioral changes of farmers in quitting chemicals. However, the lessons of communication for a major shift from the chemical ban, despite the early resistance. After some time and after proper law enforcement, farmers accept other methods and people will forget about miscommunication. This outcome can be illustrated as the model in Figure 1.

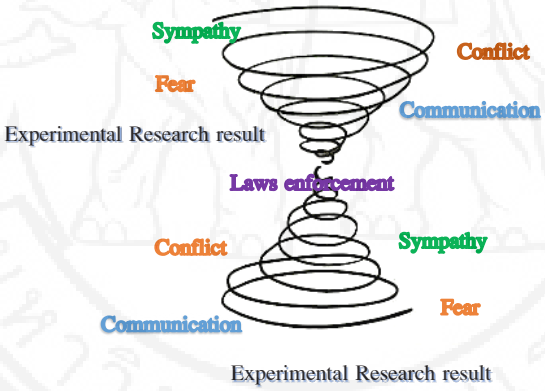

Figure 1 Reflection of the Communication Spiral

Model 1 illustrates the effects of miscommunication resulting from assessing environmental and health impacts and it is presented some part of research results through the public media in the form of news reporting. Turning to the point of a news report, the reporter must be analyzed thoroughly before it is going to the public because the facts will be affected by confusion and uncertainty in people perception. From this point of view, it can be said that the information is getting up larger as the shape of a spiral. Over time, the spiral disappears from fear, resistance becomes acceptance and change, which takes time and access to people at all levels. In every area, both through community leaders and through mass communication at the same time, it is important to consider the communication in social networks that play a vital role. The spiral of the silent model creates another surge in digital databases if the same word or text is searched and the issue comes back to the spotlight, the information will come to be a large spiral like it has occurred before. It is a failure of facts resulting an ineffective legal to eliminate the chemical usage. Farmers, who are impacted by the issues, have a dilemma and must seek information

on their own in finding chemical substitutes. It means that scientific research could not resolve environmental problems.

Miscommunication often causes chaotic activities and an important lesson for scientists and communicators is to be well aware of the perceptions that arise from miscommunication, especially for farmers and agricultural workers who have poor health because of incorrect use and handling of toxic agricultural chemicals. This demographic is often located in remote areas and frequently has low education levels.

Scientific outcomes and results will often influence particular sectors of the economy, particular groups of people in society, and benefit specific demographics. Ethical considerations in scientific communications should include standards of disclosure that ensure that this published scientific information fully reveals all aspects of the results, both positive and negative, to ensure that all stakeholders are protected from biased interpretation and wrong, ill-informed and even fraudulent use of the published data. The scientific information becomes a partial truth when such issues cause misinterpretation. This then becomes a giant communication spiral that will result in social conflict and over time, legal measures will gradually disappear, and therefore remain unresolved. If such partial truths are ultimately accepted, and other kinds of chemicals, potentially presenting similar risks, such as glufosinate ammonium for herbicides, are used to replace Paraquat, then nothing has been accomplished to protect users' health and well-being. A significant economic problem may arise when these replacement chemicals are imported at higher prices. Equally, insufficient information may be available to enable a reliable assessment of the health risks of imported chemicals, or information regarding the health risks, published and well known in foreign scientific journals, may even be ignored locally.

One unfortunate outcome of this miscommunication and information chaos is that, over time interest will fade until the issue arises anew under different circumstances. In this situation, previous criticism and misinformation may be effectively resurrected as evidence of the irrelevance of the new information. Previous voices are mute, having been silenced by the passing of time and indifference. This is the implication of the Spiral Model illustrated in Figure 1.

Suggestions

1. Government policy should support and communicate agricultural science messages regarding the environmental and health risks of agricultural chemical products, especially Paraquat. These risks must be assessed in terms of the reliability or otherwise of available science information and the uncertainty that this engenders in the public perception of these chemicals. Importantly, the food safety aspects of these chemicals must be rigorously examined.

2. Governmental scientific organizations should play an active role in assessing the validity of published research and ensure the credibility of published scientific information, and further ensure the clarity and understandability of that information to avoid the uncertainties that arise that will affect the people most at risk: i.e. the farmers and agricultural workers using these chemicals.

3. Communication sciences must correctly inform farmers of the risks, and their responsibility concerning the environment and their contribution to overcoming climate-related problems. Apart from the risks of the over-use of chemicals, other farming practices beneficial to the environment, such as tree planting and soil preservation measures, must be researched and the findings promulgated in an understandable manner. Current detrimental agricultural practices such as field burning that has resulted in widespread dangerous air pollution (at levels

exceeding PM2.5 over wide areas of northern and northwestern Thailand) also should be well publicized with scientifically proven alternatives given.

4. The turning point of communication science will be achieved when research outcomes are not accepted without challenge unless the social, economic and cultural impacts of those findings are included in the analysis of the findings. As an example, when researching the use of technology for management purposes, the successful use of that technology needs to have any countervailing problems equally assessed. As an example, in the agricultural environment, the use of drones in assisting in researching herbicide and pesticide chemical use, the use of flying drones may not apply to all types of crops and may not be suitable for all types of land and cultivation practices.

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