Up-the-Pipe Solutions: A Best Practice Framework to Engage Community to Reduce Chemical Contamination in Waste

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Article

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Abstract: Anthropogenic chemicals are fundamental to our standard of living in modern society. Unfortunately, some chemicals are persistent and can enter waste streams and ultimately the environment. Commonly used household products including pharmaceuticals and personal care products are an important source of contaminants. The aim of this study was to develop an "Up-the-pipe Solutions" framework to raise awareness about the presence and potential risks of chemicals found in household products to reduce their levels in waste streams or substitute them with less harmful alternatives. This approach based on The Natural Step framework and the concept of essentiality recognises the importance of engaging the community to raise awareness around the consequences of our daily activities and behavioural patterns that can lead to the release of persistent contaminants in main waste streams from the kitchen and bathroom and green wastes we generate.

Keywords: waste; chemical pollution; behavioural pattern; The Natural Step; survey; school; emerging contaminants; New Zealand; essentiality

1. Introduction

Chemicals play a key role in maintaining our standard of living in modern society including the use of pesticides to increase agricultural productivity [1] and pharmaceuticals and personal care products to protect and enhance human health [2]. However, the caveat to the targeted benefits gained from the use of all chemicals is based on trade-offs of the potential for some level of adverse environmental effects [3]. There are notable examples of chemicals having adverse impacts on exposed wildlife populations [4]. With nearly two thirds of the world's population living in urban areas, cities concentrate human impacts and the generation of waste that is a significant repository and emitter of a myriad of anthropogenic chemicals [5].

Commonly used household products contain many organic compounds that through normal use, and or end of life disposal, can end up in wastewater systems posing a potential risk to receiving environments and ecosystems [6-8]. One major source of chemical contaminants is from regularly used household products as part of daily domestic activities such as cooking, cleaning, personal grooming, medical care, and gardening [5]. A study looking at the contaminants contained in household solid wastes by direct sampling in the UK found that paint, pet products, pharmaceuticals, household cleaners, motor vehicle waste and printer cartridges were major sources [9]. Among the

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chemicals contained in common household products, approximately 500 are considered high production volume chemicals (HPVCs), these are manufactured in or imported into the United States in amounts equal to or greater than 450,000 kg per year [8]. Out of 26 HPVCs targeted, 20 compounds were consistently detected in the raw influents of full-scale wastewater treatment plants [8]. The long-term environmental impacts of these chemicals remain largely unknown as the methods to establish cause and effect relationships between chemical pollution and impacts on the ecosystem health are lacking or poorly described and established [10].

The key challenge is achieving the right balance between getting the full benefit of using chemicals while minimising their unintended consequences on the environment and human health. Collins et al. proposed a new approach based on "do no harm" in the use and disposal of chemicals for consideration in sustainable policy [11]. This approach builds on some fundamental principles of obligations and rights that constrain human action and provide a strong case for environmental protection as a matter of justice [11,12]. It is not a straightforward path to the sustainable management of chemicals. O'Neill described that non-utilitarian frameworks weighing up costs and benefits (even if all could be measured in a meaningful and equitable way) provide an insufficient guide to action, i.e. if harm to others breaches a fundamental obligation, it cannot simply be justified on the grounds that it maximises utility or preference satisfaction [11,12]. The development of a better chemical strategy needs careful attention to duties and rights, which are familiar features of important ethical frameworks [11].

The aim of this study was to develop a best practice framework to better inform communities about contaminants in household products that are often overlooked. It represents an initial step to building viable "Up-the-pipe Solutions" that increase awareness amongst individuals, whānau (families), community and local government of the chemical products that they routinely use as a foundation to consider more sustainable options. The framework was based on The Natural Step (TNS) and the concept of essentiality that can be applied to influence daily behavioural patterns to reduce our individual environmental footprints.

2. Materials and Methods

2.1. Community engagement context

The "Up-the-Pipe solutions" worked closely with the Kaikōura community (South Island of New Zealand), building on existing personal relationships and partnerships that members of the project team had with the Kaikōura District Council, Te Rūnanga o Kaikōura (local Māori tribal council) and the wider Kaikōura community. Previous research collaboration with these groups around waste management were particularly helpful for this project [13].

2.2. The Natural Step's Framework

The framework for strategic sustainable development (FSSD) commonly known as The Natural Step (TNS) was developed to ensure that current society's needs are met without compromising the ability of future generations to meet their needs by avoiding the degradation of ecological and social systems [14]. The Natural Step framework was developed by Swedish oncologist Dr Karl-Henrik Robért in response to the increasing seriousness of environmental and social issues facing society [15]. In the years since Robért began his work, the weight of scientific evidence has only increased [16,17]. Robért reasoned that the unsustainable behaviour of humans was due to the lack of a shared framework of what constituted sustainability [18,19].

The Natural Step framework aims to provide a mechanism for knowledge transfer, so society could gain a shared understanding of the issues facing the planet and humanity and a definition of what it is to be sustainable [15]. The framework's primary goal is that of informing communities and seeking to change minds and perspectives [20]. However, it goes one step further by providing a process for identifying solutions through collective problem solving and strategy development for a sustainable society [19] that can be implemented based on the level of communities' interest and

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ability to respond. The TNS framework is based on four system conditions in the sustainable society [21]:

Nature is not subject to systematically increasing:

1. Concentrations of substances extracted from the Earth's crust;
2. Concentrations of substances produced by society;
3. Degradation by physical means; and
4. Within society there are no structural obstacles to people's health, influence, competence, impartiality and meaning.

In essence, the TNS Framework for Strategic Sustainable Development (FSSD) is a hierarchy for planning in a complex system [22]. A useful metaphor for understanding this is a tree. The tree is part of the system and depends on the environment surrounding it for its survival, i.e. the water, the soil, and the sunlight. The tree acts as a hierarchy, ground sourced water does not enter at the leaves but works its way up the tree through the hierarchy of roots, trunk, and branches. The FSSD starts by considering:

1. the system as a whole (the tree within its surrounding environment);
2. considers the principles of what it is to be sustainable (the tree's trunk);
3. what strategy will enable society to return to sustainability once more (the branches); and
4. the actions and tools that will enable the implementation of the strategy (the leaves) [15].

On occasion people with a passionate desire to contribute will agree on the need to act then jump straight to actions. Equally people antagonistic to the idea that action is required will attempt to divert attention from the big picture by debating its details. Robért [15] refers to these instances as hiding among the leaves and argues that this achieves nothing. Instead, if we can agree on principles behind the actions and allow the actions to emerge naturally from these then we are more likely to achieve results. The TNS framework consists of a series of steps leading to a sustainable ranking of the options as illustrated by an example for 4 soap products for hand washing (Figure 1).

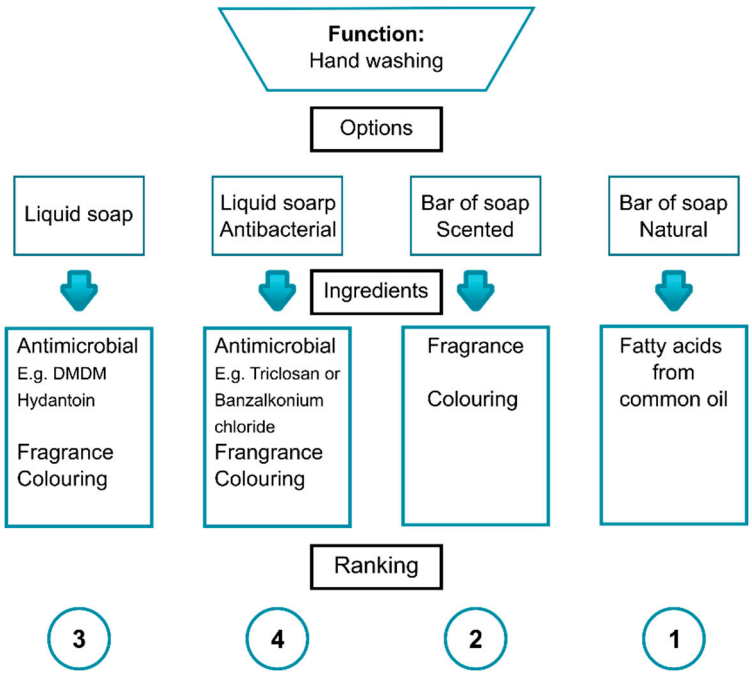

Figure 1. Schematic representation of how the TSN framework can be used and provides a ranking to assist with the decision process. In this example, the function is washing hands of which there are four soap product options that can be ranked based on the sustainability of their ingredients with 1 being most sustainable and 4, least sustainable.

2.3. Pilot educational and community engagement initiative

The Natural Step framework was used in March 2012 to underpin the community engagement process involving secondary school students, from Kaikōura High School (KHS), to characterise behavioural patterns and motivations behind the use of common household products including medication and cleaning products likely to contribute to persistent contamination in waste streams. The approach aimed to raise awareness around chemicals, characterise household behaviours, and provide learning resources to support behavioural changes using household cleaning and personal care products as case studies. A survey was designed to engage year nine educational year group (13-14 years old) to explore what waste management practices occurred in their household (e.g., recycling and composting).

The approach used the following steps:

1. An introductory presentation with two science classes from the KHS to introduce the project and present the survey and web video;
2. A survey provided to the students by their teacher to collect data and raise household awareness – "What goes down the drain in your house?";
3. A web video to set the scene for the survey by introducing the "Up-the-Pipe Solutions" focus on emerging contaminants from household waste, the journey through a municipal sewage treatment system, and the potential impacts on waterways;
4. Development of an independent classroom activity in which students were encouraged to research recipes for eco-friendly body care and cleaning products, and produce posters for entry in a competition;
5. The "Up-the-Pipe Solutions" hui (a meeting often convened by Māori) at a Marae (Māori communal facility that serves as a focus point for meetings and other cultural events).

2.4. Final community hui/workshop

The final stage of the approach was a hui at the Takahanga Marae in Kaikōura in June 2012. The hui brought together students from KHS, teachers, parents, members of the Kaikōura District Council, Innovative Waste Kaikōura staff, as well as prominent local community business owners actively involved in waste reduction, two kuia (elder statewomen) from the local rūnanga, and representatives from Enviroschools[1] and the New Zealand Council for Educational Research. This interactive workshop hui comprised of an 'ice breaker' pot scrubbing competition and four parallel workshops to take those in attendance on shared learning experiences to raise awareness of household chemicals through the local waste stream, highlighting areas where contamination occurs, how contaminants can be reduced, why we purchase products that contain contaminants, and how we can reduce contamination by using alternatives. The two kuia spoke of how cleaning was conducted in their houses when they were children approximately 70 years ago.

3. Results

3.1. Project initiation

The "Up-the-Pipe Solutions" community pilot initiative was officially launched at the KHS attended by two Year 9 science classes (approximately 60 students), several science teachers, the school principal, the local Member of Parliament for Kaikōura, a media representative, and members of the multi-disciplinary research team The project team gave a presentation and resources aimed to raise awareness of the issue of household products put down the drain and the impacts of chemicals on the receiving environment. The goal here was to demystify the wastewater treatment process, inspire young people to reflect on their own individual and household behaviours, and to provide steps for change. A short introduction to the TNS process was included in this session, and incentives

[1] https://enviroschools.org.nz/

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to complete the survey were provided in product samples gifted by Ecostore, a New Zealand based company producing eco-friendly cleaning and personal care products (https://ecostore.com/nz/).

3.2. The school survey

The survey required students to identify products used in their laundry, kitchen and bathroom that had ingredients they did not recognise or were concerned about. There was also scope to interview a parent or caregiver who was the primary household shopper about their motivations for purchasing household cleaning or personal care products. This involvement of parents and caregivers in the survey allowed the project team to engage with the wider community and gain further insights into behaviour. The survey response rate of 40% was lower than expected but within the average return of 40 or 50 % for mail surveys [23]. The results of the survey suggested that the Kaikōura community is more environmentally aware than the national average with some 90% of Kaikōura households surveyed recycling, buying refills and reducing energy use. Environmentally friendly factors were identified as important considerations in purchasing but cost and pricing were also important.

3.3. The video

To support the survey and help the students engage with the "Up-the-Pipe Solutions" concept a short film was produced. The film is an excellent resource that helped introduce and explain the "Up-the-Pipe" topic, aims and gave greater grounding and context for the survey exercise. The film involved College students, a kaumātua (Māori elder stateman) from the Ngāti Toa tribe, and a city council's wastewater management team. Referencing a successful popular New Zealand culture drink driving campaign that had a high level of recognition and uptake among youth (https://www.nzonscreen.com/title/legend-ghost-chips), this video provided a humorous but informative look at what goes down household drains, what happens in an urban waste-water treatment system, and how this can impact the quality of recreational and drinking waters. The video proved highly engaging, relevant and informative for our target audience, and was a good standalone educational resource on emerging contaminants, connections to household behaviour as well as demystifying a typical New Zealand urban wastewater treatment system. Several local and district councils requested this resource to help explain their own wastewater treatment cycle in their work with schools and community. The video is available online (https://www.youtube.com/watch?v=TNtgdJaeH3w).

3.4. The hui/workshop

The final stage was the interactive hui/workshop that included hands on activities like pot scrubbing competitions and four parallel workshops that took those in attendance on a tour through the local waste stream. It highlighted areas where contamination can occur, why we purchase products that contain contaminants, and how we can reduce contamination by using alternative options. The two kuia provided anecdotal evidence of the cleaning products and cleaning methods employed by their families and community when they were children.

Workstation 1: Alternatives for cleaning

In this session the posters that were prepared by the students were displayed and discussed. Students had been challenged to undertake their own research and produce a poster about:

- the key message from the "Up-the-Pipe" video shown;
- their family's secret natural cleaning recipe; and
- use the library or web resources to come up with their own natural cleaning recipe.

Community members then shared their approaches for natural cleaning from different perspectives. Conversations centered on how today we shower daily because we perceive we are not clean, we use anti-bacterial hand washes and sprays. Questions that were raised included: are we

dirty or unclean? Are we dirty if we are not clean? What are the implications of using so many cleaning products (e.g. linkages to increased allergies, environmental issues), and what we did in the past?

Through these exercises the students learned about alternative ways to clean both themselves and the home, with a particular focus on traditional knowledge gained from involvement of community members and whānau. It also provided a pathway to engage with the wider community that was 'meaningful', as suggested by the New Zealand's national Education Review Office: "Research evidence shows that effective partnerships between schools and parents, whānau and communities can result in better outcomes for students. The better the relationship and engagement, the more positive the impact on students' learning" [24]. It also used the "Best evidence synthesis iteration (BES)" recommendations [25]:

- That parents and teachers are involved together in children's learning; and
- That family and community knowledge is incorporated into the curriculum and teaching practices.

Workstation 2: Becoming a critical consumer

This session gave feedback to the students from their household survey results and then sought to provide tools and ways of thinking for students to become more critical consumers, where they could identify 'need' as something deliberately created by advertising, be more resilient, and look for natural treats, rather than consumer fixes. Supporting materials were developed to illustrate what models and celebrities looked like before and after airbrushing. This emphasised social and media pressures that are driving large marketing efforts to purchase products to look more attractive, while encouraging students to be aware that looking perfect was simply an advertising 'myth'.

A handout on advertising techniques was prepared and a video advert was shown to encourage students to reflect on current sales techniques and be more critical. Toxicologists outlined the potential dangers to human and environmental health from the promotion of "germophobia" in these types of advertisements that can encourage products containing more biologically active chemicals. Students were asked whether they used liquid or solid hand soaps and why? The toxicologists talked about why solid soaps were more environmentally friendly, and shared tips on good hand washing techniques (e.g., [2]). Through this activity the students were encouraged to develop critical and ethical skills or "science literacy" [26].

Workstation 3: The Natural Step

This activity involved a reminder of the four "Natural Step" conditions outlined above. Students were asked to do a back-casting activity which asked them to think of 'What should we be doing with our sewage in 2030?'

This was followed by a history of waste activity which involved the students role playing through Kaikōura's history from European settlement around 1860 to current day where students could choose to be the role of a scientist, town planner or household carer. The use of role play and 'dress-ups' helped student engagement in the activity. The students captured the historical events and implications by drawing on a giant roll of paper. They learned that managing human wastes has been an issue we have always had to deal with and that we still require more sustainable solutions.

Workstation 4: Make your own natural products

This activity gave students an opportunity to make their own low cost natural personal care products. This activity provided the students with information on basic chemistry (i.e. the properties of acids and bases) and "hands-on" learning. Some students also 'tested' their products by covering their hands in mud and then cleaning them with the lemon hand scrub. This activity was much appreciated by the students who demonstrated much enthusiasm.

[2] https://www.health.govt.nz/your-health/healthy-living/good-hygiene/hand-washing

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4. Discussion

The project was developed on the premise that increased community awareness of household contaminants and interactive shared learning experiences will support behavioural change within that community to influence the chemicals that end up being flushed down the pipe. Closing the waste loop through reduction, reuse and recovery is extremely complex. As such, policy solutions for socio-technical change that lift performance in waste minimisation and the use of less harmful chemical alternatives require multiple actions from central and local agencies, industry, community, iwi, local organisations (schools, clubs), households and individuals. Waste can be defined as a problem of 'inconspicuous consumption' that occurs around unseen and uncalculated products, services and resources associated with daily living. From a chemicals perspective there are few products that have not been enabled by chemicals in some way, e.g. to make them more attractive by giving them specific colours and fragrances and increasing shelf life by adding anti-microbials. While environmental policies and science education initiatives aim to acknowledge the unseen resources and impacts of chemical use, there is a need to involve individuals and communities for continued multi-pronged pathways for future sustainability. It has been concluded that humanity is currently operating outside the planetary boundary that are likely to lead to alterations to vital Earth system processes on which human life depends and urgent actions are required to reduce the harm [27]. To address this challenge and achieve economic and sustainable development goals will require changes in human behaviour and actions in relationship to the environment [28]. The Natural Step provides a framework to define a sustainable vision to maintain environmental and human health. The model provides objective information to individuals so that they can better evaluate the options when purchasing products. At its core lies the power of individuals to modify their behavioural patterns by making more informed decision when selecting household cleaning products through group interactions that can affect choices and ultimately environmental outcomes [28]. For instance, in a different study we asked consumers about their preference when buying cleaning products using the choice experiment technique, and all respondents stated they would pay more for liquid soap with natural ingredients that do not harm the environment [29]. Our hectic lifestyles in combination with very powerful advertising campaigns by industry have created a culture of ready to use products. The harsh competitive environment for industry has encouraged the introduction of products containing more active and persistent chemicals that when released can contribute additional pressure on the environment. The attractiveness and perceived convenience of the mainstream products make it difficult for individuals to impartially identify the options available and their sustainability.

A recent study linked the average lifetime citizen carbon emission to the future exposure of people to unprecedented heat [30]. Households are a key source and represent a major carbon emission source from a range of obvious and hidden sources (Figure 2). Mitigation options in areas like housing, mobility, food and other consumptions can lead to major carbon emission reductions while reducing costs [31]. For instance, our diet and the pets we own can substantially increase household footprints especially in terms of carbon emission [32,33]. There is an urgent need for shifts in behaviour and responsibility if communities are to meet the social, economic, cultural and environmental needs required to meet global sustainability targets and reduce our footprint. While improving the hard infrastructure provides the structure for a settlement to be more sustainable, it will not by itself lead to sustainability. Instead, the energy of the communities living within the settlements must be mobilised if the changes required are to happen.

Acknowledging these assumptions, it is also important to note that the agency of individuals and their actual power to make change is determined by a range of factors including socio-economic status and cultural determinants etc. Working with communities to build stronger pathways for collaborative collective action was also an underpinning orientation of the participatory methods used in this intervention. Whilst there is merit and power in individual / community behavioural approaches, we note that transformative policy changes are also imperative to achieve sustainable change.

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Figure 2. Average family household with the multiple sources of carbon emission.

The "Up-the-Pipe Solutions" concept aimed to assist the community to take greater ownership and responsibility of their wastes by better characterising behavioural patterns, alternative products and infrastructures that could help reduce persistent and toxic contaminants in waste streams and ultimately the environment. It is difficult to engage with "community" on waste, as such issues tend to lack salience unless there is an obvious crisis, and arguably it is in the public interest for the costs of waste disposal to remain hidden [34]. By implementing TNS framework, it is embedded in the concept of essentiality. The essentiality nature of elements like vitamins and minerals is to maintain physiological health. It is well established that deficiencies of essential elements can result in a range of clinical symptoms [35]. This fundamental concept has been well described for metals and the window of essentiality ([36], Figure 3).

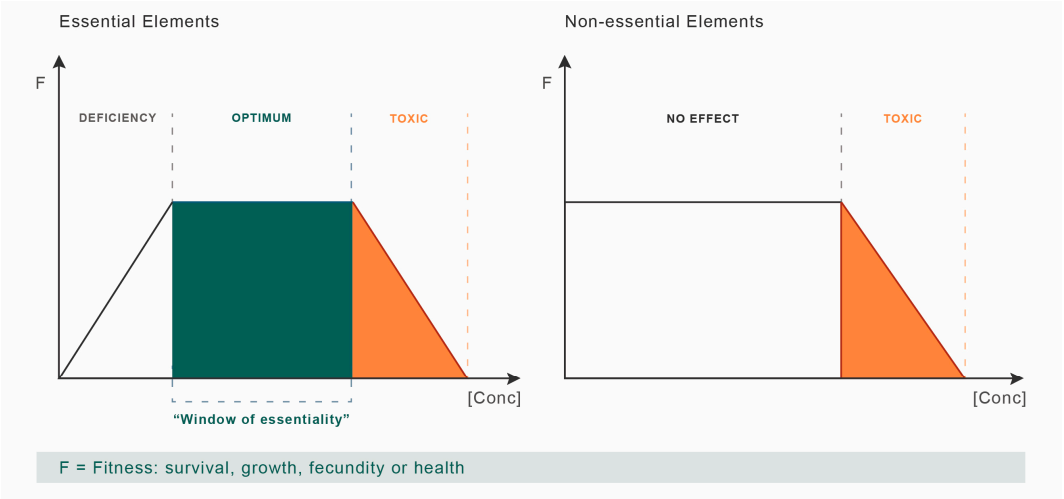

Figure 3. The concept of the window of essentiality for metals. The left panel describes the concentration range of essential metals like zinc and copper that is optimum to maintaining the health of an organism which is mainly based on its ability to reproduce. Concentrations outside this range are detrimental to the fitness of the organism. The right panel describes how organisms cope with non-essential elements and when they reach a level where the defense mechanisms are overwhelmed.

An essential-use approach has been proposed for chemicals of concern based on whether the chemical is "necessary for health, safety or is critical for the functioning of society" [37]. The essential-use concept has been used to investigate problematic chemicals like poly- and perfluoroalkyl substances (PFAS) that are highly persistent or transformed into persistent compounds in the receiving environment [38,39]. An essential use approach also aligns with the concept of Māori kaitiakitanga, a principle which expects reciprocal and balanced relationship with the environment [40,41]. These all add up to make the "Up-the-Pipe Solutions" a complementary framework to engage with the community on sustainability issues and identify what is essentiality based on key values as defined in TNS. Alongside much needed global policy changes, such approaches can support individuals and communities to develop good habits when facing choices so that the unintended consequences are minimized. It can be simple changes like switching from liquid pump to cake soaps, reducing amounts used, or reincorporating basic cleaning ingredients such as baking soda and white vinegar. These small transitional changes are cumulative and can lend momentum towards transformative global policy action needed to reverse the considerable uncalculated environmental costs of human activities and chemical use [32].

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