Chemical Literacy: Fiji's Basic Science Teachers' Professional Practice in Chemical Management

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Abstract

The study investigated the level of chemical literacy of lower secondary Science teachers through their professional practice with chemical management in schools. The study sample consisted of 70 schools in the Western Viti Levu Education districts in Fiji. The participants' perception of chemical literacy and their practice with chemicals in their Basic Science teaching and learning was studied. The participants were found to have very low levels of scientific literacy. Such low levels are insufficient for the development of personal, social and societal domain of chemical literacy in learners.

Introduction

In science education, chemistry (chemical education) is recognized as a very important school subject. Chemistry's significance in scientific and technological development is critical. In Fiji, Chemistry forms an important component in the Basic Science curriculum; this is a mandatory subject for students in years 9 and 10 of their formal education programme (forms 3 and 4). From form 5, Chemistry is a stand alone core subject among the natural sciences. A similar trend is found in many countries in the world (Adesoji and Olatunbosun, 2008; Ministry of Education, 1997; and Emovon, 1985).

Chemical education reforms suggest that context plays an important role in the usefulness of learning outcomes in Chemistry to the learners and the learning experiences that learners get (Jong,

2006). It is claimed that there are basically four domains of origin of context:

1. *Personal domain,* where students are able to connect chemistry with their personal lives such as understanding of emergency procedures to follow when exposed to hazardous chemicals; often this is related to personal health care;
2. *Social/Societal domain,* where schools play a role in preparing students to become responsible citizens; here, for instance, the student could connect chemistry to environmental issues such as acid rain, global warming, and green house phenomenon;
3. *Professional practice domain,* which relates to the role of schools in preparing students for employment in private and public sectors such as test chemical contamination in food and water; and
4. *Scientific and technological domain,* which relates to the role that schools play in developing students' technological and scientific literacy skills; this refers to the students' ability to contribute to and make sound decisions on scientific issues of importance globally (Jong, 2006).

Irrespective of the origin of the domain of context, the purpose for teaching Chemistry ultimately is to develop a chemically literate individual who is a more informed citizen who can understand reports, discuss about Chemistry in media, and can better understand prevalent environmental issues. Understanding Chemistry is critical since our physical environment is heavily affected by chemical processes and chemical products (Gilbert and Treagust, 2009). Understanding Chemistry and the ability to apply that understanding to daily life is what is referred to as Chemical Literacy (CL) (Tsaparlis, 2000).

While all the domains are interdependent and intertwined in their focus, for this research we consider the first two domains only. Our focus in this paper is on lower secondary level; hence we consider the personal, social and societal domains to be more appropriate for the examination of Basic Science. We argue that focusing on these two domains of development in Basic Science education would enable learners to perceive Chemistry as meaningful, contributing towards development of CL, and encouraging students to choose Chemistry related career paths (Adesoji, 1999; Johnstone, 2000; and Holbrook, 2005).

With the goal of achieving CL, the focus of Chemistry education in Basic Sciences covers a wide range of intended targets in the intellectual, personal and social domains. Holbrook cautions that although conceptual learning in Chemistry is given importance, the learning and teaching 'must not lose sight of the fact that the attitudes, communication abilities and personal attributes (such as creativity, initiative, safe working) need to be developed' (2005**:** 4). This suggests that learning and teaching of Chemistry ought to be done within the personal, social and societal domains.

The World Health Organization (WHO), the United Nations Environment Programme (UNEP) and the International Labour Organization (ILO) have expressed concern that children tend to touch, test and explore their surroundings, getting in contact with toxic chemicals unsafely used or stored (WHO, 2004). They recommend that since Chemistry and chemicals have a central place in science, safe chemical practices should be the most basic and fundamental part of any lesson. They also strongly emphasize that good chemical safety habits taught early prepares students to learn to work safely, developing their individual sense of responsibility and good habits for safe handling and use of chemicals. Thus, the development of such desirable attributes in children from an early age is important.

According to Adesoji and Olatunbosun, in any 'teaching - learning situation, the students, the teachers, the curriculum and the learning environment are the four pivots' (2008: 16). Hattie (2003) aptly says that teachers are the single most important source of variation in the quality of learning. Papanastasiou affirms that teacher's role during the learning process can directly or indirectly influence student attitude and hence student learning outcomes; teachers are 'role models whose behaviors are easily mimicked by students' (2001: 20). Teachers, therefore, play an important role in the development of chemical literacy. Their knowledge and understanding of chemicals would certainly impact on the development of the same in learners. On the basis of a research conducted on teacher's perception of student evaluation of teaching, Joshua and Basey (2004) conclude that teachers are an indispensable member of the school organizational team as the effectiveness of any system is dependent on the quality of the individual teachers delivering the service.

Since teachers are considered such an important variable in student learning, it is important that teachers are good role models who have appropriate cognition, skills and behavior when teaching about and handling chemicals while teaching Basic Science. If

teachers have appropriate chemical management skills than students would very likely develop favorable knowledge, skills and disposition towards the impact of chemicals in their personal and public lives as well as be groomed to understand their impacts on the environment. Teacher's knowledge and practices with chemicals in Basic Science affects how they behave and how they interact with students which in turn sends important messages to students about the importance and value of chemical education.

This study, thus, considered teachers knowledge, understanding and practices of chemical management a critical starting point for the development of CL.

The Study

This study investigated the level of CL of Basic Science teachers by ascertaining teachers' knowledge and practices with chemical management practices in schools. The following questions guided the study:

1. What is the Basic Science teacher's perception of chemical literacy?
2. How familiar is the teacher with the Material Safety Data Sheet (MSDS) of chemicals that are used in Basic Science classes?
3. How does the teacher use his/her understanding of chemical management in his/her professional practices?
4. How relevant is the Ministry of Educations' Occupational Health and Safety Policy in developing a culture of safe practice in chemical management?

There is a dearth of local literature in this area of study. This is the first research of its nature that has been undertaken in Fiji. This study, therefore, will create awareness on the importance of educating the Basic Science teachers on Material Safety Data Sheet (MSDS).

The study used a triangulation mixed method design, which is a procedure for collecting, analyzing, and 'mixing' both quantitative and qualitative research and methods in a single study to understand a research problem (Creswell, 2006, Johnson, Onwuegbuzie & Turner, 2007). Triangulation design is used where data is obtained differently using qualitative and quantitative tools but the data complemented the same topic; this design is also referred to as the 'concurrent triangulation design (Creswell, 2006: 64).

The population boundary for the study was the schools in the Western Division of Viti Levu, the largest Island in Fiji. This division comprises four districts, namely Nadroga/Navosa, Ba/Tavua; Lautoka/Nadi/Yasawa; and Ra. From the population sample, 25% of the Primary and 25% of the Secondary schools were randomly selected for data collection. The sample comprised of 54 Primary schools and 16 Secondary schools. A large sample was taken to validate the findings of a similar research by Shah and Sharma (2010) to ensure that the findings can be generalized for all the schools in Fiji.

For the primary schools, the target group was upper primary (classes 7 and 8) Basic Science teachers, while for the secondary schools, the target group was the lower secondary (Forms 1-4) Basic science teachers.[1] Specific mention has been made to Primary and Secondary schools when distinction in data was noted between the two; the general term, 'lower Secondary' is used otherwise.

Qualitative data was derived from semi-structured interviews of department heads (secondary) and science teacher-in-charge (primary), as well as through observation of the science laboratories and science cupboards/classrooms. Documentary analysis of the education ministry's School Occupational Health and Safety (OHS) Policy and Chemical inventory logs were done.

The quantitative data was derived from questionnaire survey. Questionnaires were given to the Basic Science teachers; they were asked to fill the questionnaires under the researcher’s supervision. This was done to eliminate any form of bias and external influence that could have affected the results. The number of questionnaires depended on the school size and the availability of the Basic Science teachers.

The researchers’ valued both the forms of data; an almost equal weighting was given to both the quantitative and qualitative analysis. The questionnaires were analyzed quantitatively and the data obtained from the semi structured interviews, observations and documentary analysis was analyzed qualitatively. Quantitative data

[1] In Fiji, some primary schools have classes 7 and 8, while some have only to class 6. From the latter, students enter Forms 1 & 2, which essentially has the same curriculum as that in classes 7 & 8 respectively. Collectively, for the purpose of this study, we refer to classes 7 & 8, and Forms 1 to 4, as lower secondary.

was merged with the qualitative data during the analysis to obtain a better picture of the problem that was being investigated (Creswell, 2005).

The Theory

Scientific Literacy

Theory on scientific literacy and chemical literacy provide the theoretical basis for this study. Scientific literacy refers to the possession of knowledge to understand the interrelationship between scientific facts and science, technology and society and the ability to apply it to real world problems (Bond, 1989; Celik and Bayrakceken, 2012). Scientific literacy is one of those terms often used but seldom defined (Miller as in Anelli (2011: 238). What best fits this study is: 'Science education should focus on the “usefulness aspect” of scientific literacy; that is, the degree to which science education actually helps people solve personally meaningful, everyday problems and make important science-related decisions' Feinstein (2011: 170-171).

The primary goal of science education is to participate in the education of citizens as ‘lifelong learners’, who should be competent in knowledge and skills and be able to make decisions and participate in public debates on science and socio-scientific issues. As scientific literacy is a broad concept, teaching any special subject in science education should contribute to the goal of training scientifically literate people. Teaching Chemistry contributes to chemical literacy in particular, and to scientific literacy in general (Shwartz; et. al 2006).

Schwartz et al. (2006) and DeBoer (2000), summarisng the many proposition made by other researchers, suggest that there are basically 3 distinct levels of scientific literacy at which an individual can operate; these are: *practical or functional literacy,* which refers to the ability of a person to function normally in his/her daily life as a consumer of scientific and technological products, such as food, health, and shelter; *civil literacy,* which refers to the ability of a person to participate wisely in a social discourse concerning scientific and technologically related issues; and *cultural or ideal literacy,* which includes an appreciation of the scientific endeavor, and the perception of science as a major intellectual activity.

Bybee (1997) and the Biological Science Curriculum Studies

(1993) suggested a comprehensive theoretical scale that is more suitable for the assessment of scientific literacy during science studies at school, as its hierarchy can be easily transferred to instructional purposes. This study considered the scale useful in ascertaining teacher's level of chemical literacy. The scale, from the lowest to the highest level, is as follows:

- *Scientific illiteracy*: Students who cannot relate to, or respond to a reasonable question about science. They do not have the vocabulary, concepts, contexts, or cognitive capacity to identify the question as scientific.
- *Nominal scientific literacy.* Students recognize a concept as related to science, but the level of understanding clearly indicates misconceptions.
- *Functional scientific literacy.* Students can describe a concept correctly, but have a limited understanding of it.
- *Conceptual scientific literacy.* Students develop some understanding of the major conceptual schemes of a discipline and relate those schemes to their general understanding of science. Procedural abilities and understanding of the processes of scientific inquiry and technological design are also included in this level of literacy.
- *Multidimensional scientific literacy.* This perspective incorporates an understanding of science that extends beyond the concepts of scientific disciplines and procedures of scientific investigation. It includes philosophical, historical, and social dimensions of science and technology. Here students develop some understanding and appreciation of science and technology regarding its relationship to their daily lives. More specifically, they begin to make connections within scientific disciplines, and between science, technology, and the larger issues challenging society (Shwartz, Ben-Zvi, and Hofstein, 2006: 204).

Since primary education is the starting point for the development of scientific literacy, the development of the lowest level is important. As early as in 1934, Dewey called for educators to train all students to develop a 'scientific attitude' or 'habit of mind', such that they would exhibit 'open-mindedness, intellectual integrity, observation, and interest in testing their opinions and beliefs (as in Anelli, 2011: 2356). As stated earlier, the sooner this development

begins in a child's education programme, the better it is (WHO, 2004).

Anelli (2011: 238) along with several experts including the National Science Education Standards (NSES), provide compelling arguments for the importance of scientific literacy; they are firm in the belief that all students deserve the opportunity to become scientifically literate.

Chemical Management (CM)

Development of good chemical management skill is important in Basic Science lessons. Lessons which are activity oriented and authentic are appealing. Chemistry is recognised as a basic experimental science where experimentation is a basic method of school work (Šorgo and Špernjak, 2012; Liapi and Tsaparlis, 2007). The experimental nature of Chemistry implies that chemicals will be used in science classes. Hence the management of chemicals become important in promoting CL.

Chemical management is a plan that identifies, manages, and prevents hazards through all stages of chemical purchasing, storage, use, and disposal. According to EPA (2006), CM is critical to controlling a variety of environmental, health, and safety issues within any school. The knowledge of what sort of materials are present in schools and how they are used, stored, and discarded develops an understanding of the issues associated with these substances. Properly recognizing and controlling the hazards inherent to these materials, enhances the schools ability to create a safe school with minimal environmental liabilities/lawsuits (EPA, 2006).

Chemicals are accompanied with a Material Safety Data Sheet (MSDS), which is a document relating to a chemical substance that covers the chemical composition of the product, its name and essential physical properties, such as boiling point, vapour pressure, reactivity and odour. Furthermore, it defines hazards, including fire and exposure, and safety measures, including protective gear, associated with the chemical substance. MSDS provide the necessary information for one to understand and deal with the potential hazards associated with a particular substance (Volland, 2008).

The importance of MSDS is twofold. On one hand, it provides employees with all the necessary information they need to ensure they are using a product correctly, while simultaneously it informs employees of ways to protect themselves from the hazards of the product by providing safe handling and storage procedures, procedures in cases of emergency or fire, and what personal protective equipment needs to be worn when dealing with these chemicals.

Chemicals can be very dangerous, especially if they are being repeatedly handled without proper procedures. They can pose many health and physical risks. In addition, having general knowledge about the product, such as colour, physical state, or flashpoint, will help ensure a safer work environment for those involved. MSDS is also important when it comes to emergency responders or medical personnel (Volland, 2008).

A survey of K-12 schools in 55 states in USA found that a large majority of middle and high schools had out-dated, unknown, improperly stored or unnecessary chemicals, with potential of high risk (EPA, 2006). Similar findings were recorded by Michigan Department of Environmental Quality (DEQ, 2009) and National Research Council (NRC, 2011).

According to EPA (2006) and DEQ (2009) some important components of proper CM are chemical inventories; chemical cleanout and disposal; proper labelling, storage, and handling; purchasing guidelines, chemical safety and training and education. These components along with many others, play a significant role in developing a proactive attitude towards chemicals amongst teachers.

Role of the Organization

Leaders play a significant role in ensuring safety for their workers. It is the responsibility of the employer to ensure that the MSDS sheets are available to the workers; that the workers acknowledge their existence, and that they are educated on the potential hazards exposure in the workplace. A supportive culture is needed to graft a safety culture onto an organization (Department of Consumer and Employment Protection, 2007).

Both personal and organisational attitude affect the development of a safety culture in a workplace. The environment in which people work and the systems and processes in an organisation also influence the safety culture. Safety is a shared responsibility between teachers, students, administrators, and parents and should be a national, district and school policy, not the policy of an individual teacher only (EPA, 2006 and DEQ, 2009). Organizational chemical management policy may contribute to the development of a safety culture. In the US, all states, districts and schools are mandated to

have a CM policy (EPA 2006). Organisational attitude can positively influence personal attitude of teachers and learners.

Many teachers and administrators give low priority to the understanding of regulations, best classroom practice, and facilities preparation for safety with chemicals (Trammell, 1995). School science accidents have been attributed to several factors, namely (a) new performance-based science standards that require more hands-on work in laboratories, (b) inadequate safety equipment in schools, and (c) lack of adequate training of teachers. Ongoing professional development and training are important in the development of positive attitudes of safety culture.

Gerlovich (2002) found that over half of the science teachers in his survey of 18 states in the US had never been trained on safety. He further found that many high school chemistry teachers had primary degrees in other fields and might have only taken two years of college Chemistry.

In case of Fiji, primary teachers are trained as generalist teachers. In addition, those who never studied any pure science in secondary schools teach Basic Science for year 7 and 8 after completing their teacher training courses. This fact itself raises fundamental questions on the competency of these teachers in CM. The undergraduate training program for primary teachers needs a clear re-examination.

Safety in the science laboratory requires common sense, preparation, and knowledge on the part of both the teacher and students. The use of unfamiliar equipment and chemicals in the science laboratory requires extra rules for behaviour (Trammell, 1995). Teaching students the proper way to handle materials in the school laboratory should also help them learn correct handling of chemicals found at home or on the job. Safety education must be an ongoing process and cannot be done only once during the year. Students cannot be expected to remember everything from the safety lecture given during the first week of class. Like any other activity, safety is learned only by continual reinforcement (Trammell, 1995). The implication is that safety must be continuously practiced intentionally by teachers to develop the same attribute amongst students who can later use this understanding

MSDS is a document relating to a chemical substance that covers the chemical composition of the product, its name and essential physical properties, such as boiling point, vapour pressure, reactivity and odour. It also defines the hazards including fire, exposure and safety measures, including protective gear, associated with the chemical substance. The MSDS provides the necessary information for one to understand and deal with the potential hazards associated with a particular substance (Volland, 2008).

Many may argue that in Basic Science curriculum chemicals are not potentially hazardous. However, a list by EPA (2006) of the top forty risk chemicals in schools shows that there are a significant number of potentially hazardous chemicals used in Basic Science experiments, including sulphuric acid, acetic acid, mercury thermometer and hydrochloric acid.

In a study of intermediate school cupboards clean-up in all states in USA, the EPA (2006) found a large number of school science storage containing chemicals such as asbestos, unknown radioactive chemicals , and many carcinogenic chemicals unknown and improperly stored in cupboards as it passed on from one teacher in authority to another. It is possible that a critical look at the science inventory recording system and science cupboards in schools may show teachers the existence of many chemicals that are old, unused and potentially dangerous in schools in Fiji.

Survey Outcome

Teacher knowledge of Chemical Literacy (CL)

All the teachers in the study were able to explain the meaning of Chemical Literacy (CL) to a limited extent (N=70). Their meaning captured explanations on the labelling, storing, disposing and handling of chemicals and their effect on the environment. However, the role that CL plays in developing the domains of origin of context (Jong, 2006) are unclear. Teachers' definition associated CL with only the use of chemicals and not on the usefulness of Chemistry as a subject at the four domain of origin of context.

Familiarity with Material Safety Data Sheet (MSDS) of chemicals

Although all the teachers were able to explain their understanding of chemical literacy, albeit an incomplete understanding, as the ability to label, store, dispose and handle chemical safely, only 53% of the surveyed population (N=37) had MSDS awareness especially when purchasing chemicals. 44% of upper primary teachers (N=24 out of 54) and 79% of lower secondary teachers (N=13 out of

16) had MSDS awareness. More than half the primary school teachers, therefore, were found to be unaware of MSDS, indicating a lack of training and explicit awareness at the organisational level. This indicates a need for including chemical management education in pre-service and in-service teacher training programmes.

In the same vein, 90% of the population (N=63) knew the purpose of MSDS; however, their interpretation skill of MSDS was questionable. 96% of the interviewees (N=70) could not interpret the contents of MSDS when given a sample MSDS. For example, when the toxicological information about 'copper sulphate [LD 50:300mg/kg-rat]' was given, teachers pointed out that the chemical was toxic by recognizing the term ‘toxic’ in the term toxicology but were unable to interpret the numerical value of LD (lethal dose) that can kill a rat and what it means when they are using it in class. Similar explanations were given to terms such as carcinogenity of substances.

The understanding of science terminology appears to be at surface level where definitions can be acquired but the application of the meaningful use appears to be poor indicating the need for explicit awareness of MSDS. Volland (2008) and EPA (2006) give support that MSDS training at organisational level can improve CM practices of teachers as MSDS is one of the important components of safe CM practices.

The teachers thus appear to be operating at the lowest levels of SL; nominal /functional literacy (Schwartz et al., 2006; DeBoer, 2000). With this level of understanding of chemicals teachers use in science classes, it is thus doubtful that teachers are focussing on the development of CL in students targeting their personal, and the social and societal domain (Jong, 2006).

The ensuing discussions and results show CM practices in school which confirms the doubt above.

Firstly, it was established that chemical companies that supply chemicals to the schools do not supply MSDS to schools. 5% of the sample (N=4 out of 70) do request for MSDS from chemical suppliers. But none succeeded in getting the documents. Some teachers downloaded the MSDS from the internet mostly from personal sources as most schools are not adequately equipped with internet facilities. This finding shows a very clear organisational non-functionality in this regard.

When asked about their access to MSDS, 95% stated that they do not have MSDS access in their schools. They stated that they sometimes rely on the labels of the chemical containers for information about the chemicals and relate the same to their student. The labels on chemicals, however, have limited information whilst the MSDS has detailed and complete information deemed important for proactive planning. Of those teachers who had access to MSDS, some stated that the MSDS in schools are stored in the science laboratory files (N=3). However, some stated that these are with the head of department, and they need to ask for this from them. The lack of readily available MSDS with the teachers is a serious handicap to their ability to advance CL.

Teacher's use of Chemical Management in Professional Practice

Chemical handling and disposal in schools

After a scientific investigation in class, 99% of the teachers mentioned that they dilute chemicals before discarding (N=69). A high 78% (N=54) stated that they discard chemicals in either sinks or in drains. This means that the discards eventually make their way into nearby drains and/or water bodies near the schools. The remaining 22% (N=15) teachers get students to discard the chemicals on the ground, in incinerators, in soak pits and even in pit latrines after dilution. These teachers considered discarding chemicals in such areas as 'safe'; one factor declaring these areas as safe was the minimal student access to these areas. This is more common in rural and remote schools. It is a concern that teachers seem to be ignorant in their responsibility for environmental awareness in CM which is a social responsibility, an important component of CL (Jong, 2006).

Use of students to carry chemicals is a habit. More than 80% (N>56) of the surveyed schools used students to dispose chemicals after investigations. Most primary schools used their students to carry chemicals to and fro classrooms, in some cases unsupervised. This practice is unsafe and is not compliant with the Occupational Health and Safety (OH&S) Policy (MoE, 1997). The OH&S policy (MoE, 1997) states clearly the role of teachers and schools pertaining to safety in laboratories: 'Teachers who want to use the science materials/equipment should personally take materials from the teacher in charge. Extreme care must be taken when moving chemicals from one room to another. All safety regulations must be displayed and followed' (MoE, 1997).

Several issues arise from the above data. First, the Policy

seems to assume that teachers are aware of the safety regulations for proper chemical management. This assumption is ill-founded, as it has been established that teachers' conception of safety with chemicals is restricted to student safety whilst it is being used during lessons. Although, all teachers were found to be very particular about safety of students during experiments, this was not reflected in their actions, as students were used to carry chemicals to and from their classrooms, as well as dispose and clean glassware containing the chemicals. Secondly, students were exposed to chemicals without even having proper PPEs. PPEs for students in schools is missing entirely. The third issue concerns the lack of any explicit protocol for chemical usage and disposal in the Ministry's OHS Policy. This leads to teacher ignorance of the appropriate ways of exhibiting safe behavior for chemical use. All schools have the OHS Policy displayed but safe practices were not the norm.

It is well accepted in the scientific community that safety with chemicals is as much for individuals as it is for all the living things in the community. When put broadly it must be linked to the society and the environment. The absence of teacher concern on storage, usage, and disposal, and their impact on the environment and other living things was widespread. Teachers' self-skill in chemical safety was not apparent. One of the most important factors in effective learning is teachers as role models. Safety only when using chemicals may send an incorrect message on the safe use of chemicals. Safe use of chemical is more than personal safety (Jong 2006). It is reiterated that the teacher's behavior towards chemical usage sends very important messages about the purpose of chemical education to students (Hattie, 2003; Jong 2006; Joshua and Basey, 2004; and Papanastasiou, 2001). In the Fiji case, chemical education did not emphasise the development of the social and the societal domain (Jong, 2006).

Chemical Storage in Schools

Results show that chemical storage is most problematic; this must be considered a major issue in CM practices. Chemicals were found to be stacked together irrespective of their class and property in 90% of the surveyed schools. None of the primary schools visited, had proper chemical storage. Chemicals were stacked in cabinets or open cupboards, with least concern given to the class of chemicals. It was also established that many chemical containers were so old that there were cracks in the containers and the contents were spilling out. In some schools chemicals were not stored in properly labeled bottles, or non-standard bottles were used for chemical storage. Science chemical cabinets were stacked with both chemicals and science equipment, especially for upper primary schools.

For the secondary schools, chemicals were stored separately from the equipment and glassware in most cases. In about 10% of the schools (N=2 out of 16), chemicals were stored according to their class; this was noted for those teachers who had an awareness of MSDS. In the other 90% (N=14 out of 16), chemicals were stored according to alphabetical order, which meant that different class and property of chemicals were stacked together.

Furthermore, the designs of the science chemical cabinets were ad hoc; none were of industry/professional standard. Some science chemical cabinets had a height exceeding 2m, with the chemicals placed on the top shelves, requiring the use of stools or benches. This in itself posed risk and was an OHS issue (DEQ, 2009; EPA, 2006; and WHO, 2004).

The location of the storage area was also contrary to good chemical management practices. In all the primary schools, location was inappropriate. Cupboards/cabinets were stored in public places such as the library, staff room or even classrooms. Students were also given permission to remove or put back the chemicals from these cabinets before and after use in classes.

Secondary schools had proper chemicals storage facilities. The Basic Science teachers were normally responsible for removing chemicals from the science cupboards; however most of the time they asked students to carry these for them.

There was also poor ventilation in places where chemicals had been stored especially for primary schools and certain secondary schools.

Storage of expired and excessive chemicals was also investigated. In some schools, chemicals like nitric acid had been stored for so long that they actually leached out of the bottles. In some cases, chemicals had decomposed in their respective bottles, with the teachers unaware of action to be taken. Overall, most of the secondary schools had chemicals in excess of the required amounts. This is consistent with the findings of EPA (2006) which found that high schools usually have larger inventories and more hazardous chemicals than middle and elementary school (EPA, 2006).

While none of the primary schools had excess storage of chemicals, they did have very old, unlabeled chemicals in small quantities. Here too, these unlabeled chemicals, as the EPA (2006) found out for the USA, could be anything and can only be identified by chemical experts during a chemical cleanout. In addition, most of the chemicals that were labeled in primary school science cupboards were either expired or near to their expiry date.

Interviews with teachers during science cupboard observations showed that there was confusion between liquid and solid chemicals. A significant 19% (N=10/54) regarded only liquids as chemicals. Although this represents only a little less than one fifth of the upper primary teachers surveyed, teachers can be a significant source of misconception for students in the primary schools (Skamp, 2004). Furthermore, this also raises the concern about the handling of solid chemicals especially if it is not considered a chemical.

Chemical inventory is an important aspect of Chemical storage. Observations of chemical inventory records show that none of the participants in the study had proper records. Records were limited to the names of the chemicals and the date of receipt.

Inventory of chemicals is more than a record of resources. It must be a living document where status of chemical after every use is updated. A chemical inventory

> identifies the quantities and physical locations of, as well as the potential hazards associated with, all of the chemicals used and stored in a school. It also serves as a reference for school and emergency personnel (e.g., local fire department) in the event of an emergency. Furthermore, a chemical inventory, when used to guide necessary purchases, can reduce the costs and management needs associated with excess chemicals (EPA,2006: 72).

The limited nature of the inventory records in the schools in Fiji could possibly be related to the storage of excessive and outdated chemicals in schools.

Laboratory Safety accessories/Necessities/Professional development

In a majority of the secondary schools visited, the presence of safety accessories such as fire extinguishers, buckets of sand (in case of a fire), safety showers, fire blankets and first aid kits were noted. This was an indication that teachers were aware of safety issues around work areas. However, it was seen that in most primary schools, equipment such as a fire extinguisher and first aid kits had been placed in the head teacher's office. Since primary schools do not have a separate science space, consideration of safety accessories in every classroom was not the norm.

Training on safe CM practices is not given importance in promoting a safe working environment. Data shows that although teachers are briefed on OHS issues in every staff meeting and students' safety issues are given high importance, all the participants reported that training about chemical and chemical management has never been raised as an issue of importance. About 30% (N=21) of the teachers do remember participating in one professional development workshop organised by the Curriculum Development Unit some time ago. Continuous emphasis and training is essential in the development of proper CM practices (Trammell, 1995).

It could be that the MoE assumes that teachers' have been trained on proper CM in their teacher training programmes. But even if they were, continuous professional development of teachers is necessary for sustaining practices that can enhance the learning outcomes of education (Darling-Hammond, et. al., 2009).

Safety contract

One secondary school in the sample asked students to sign a laboratory contract with the Science Department of the school. This science department had its own departmental policy and accident report form, which had to be followed by the signatories. This ensured good laboratory practice for the department and the school. When inquired, it was established that the teacher responsible had acquired this safe practice through University education in the undergraduate science program.

Conclusion

Teachers are instrumental in developing Chemical Literacy in learners. The broad goal of science education is raising chemical literacy. This study looked at teacher's perception and practices of chemical literacy in schools. The study was based on the premise that teacher's level of chemical management practices was a window through which their competency of chemical literacy, and broadly scientific literacy, could be assessed.

The study found that the participants had very low levels of

scientific literacy. The participants were operating between the nominal and functional literacy levels. Their understanding of chemicals and their meaningful use was limited and clouded with misconceptions. This is a serious issue on science teaching in lower secondary schools. Teachers are role models for students. The importance of teachers with conceptual understanding of the subject matter, in this case proper chemical management, influence significantly the type of learning environment given to students. The study found that the current chemical management practices of the participant are focussed neither on the personal domain nor on the social and societal domain of chemical literacy. This does not augur well for encouraging science education in the country. A sustained emphasis on the development of the personal and social domains of literacy will ultimately contribute to the development of scientific literacy.

Although the study was limited to the schools in the Western Division of Viti Levu, it is suggested that since there is nothing unique in the other divisions in terms of training and environment, the findings can be generalized. These findings are also consistent with the findings of Shah and Sharma (2010), though the latter was on a smaller scale.

The study found that there may be several factors that are contributing to the low levels of chemical literacy in the participants. They are as follows: (a) the lack of explicit policies on chemical management, (b) the lack of continuous training and education explicitly on chemical management, and (c) the lack of importance and emphasis given to chemical management in schools.

The study also established that chemical management practices in schools are in a state that do not meet the simplest test of acceptability. That so far major accidents have not occurred is not any cause for joy. If anything, the draining of chemicals into the environment around the school should be a major concern. Chemical management, as the EPA (2006) and the WHO (2004) recommend, needs to be proactive rather than reactive.

The need for a thorough review of the current Occupational Health and Safety Policy is a high priority. This policy was issued in 1997, when the OHS legislation was newly enacted in the country. The review needs to include chemical management as a priority area in creating a safe and healthy working environment A National Chemical Management policy may be also a matter for consideration.

Another implication of this research relates to the adequacy of getting teachers with no prior background in science other than the exposure in primary teacher training programmes, to teach science. Exhibiting appropriate chemical management behavior is not a casual affair. It must be consciously practiced by the most influential variable of teaching and learning: the teachers. Without formal training in this area, one can not expect teachers to become proficient. At the very least, continuous professional development activities for teachers need to be initiated to increase the level of scientific and chemical literacies. The requirement to successfully complete professional development programmes in these areas can also become a requirement for continuing registration of teachers under the Fiji Teachers Registration Board.

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