ASSESSMENT OF STATUS AND PRACTICES OF CHEMISTRY LABORATORY ORGANIZATION AND UTILIZATION IN 'ADET' AND 'DEBREMEWII' SECONDARY SCHOOLS, AMHARA REGION, ETHIOPIA

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ABSTRACT

This study intends to assess the availability of Chemistry laboratories in schools, extent of applying laboratory and its resources in teaching chemistry subject, and the problems confronted in using chemistry laboratories in the teaching and learning process of the subject chemistry in 'Adet' and 'Debremewii' secondary school, Amhara region, Ethiopia. The study also examines the practices of organizing and utilizing chemistry laboratory in the schools. A mixed method research approach was used. The study was targeted two government higher secondary schools ('Adet' and 'Debremewii' secondary school). The respondents were all chemistry teachers, one department heads, one chemistry laboratory technicians, and 20 students from each school of grades 9 and 10. Questionnaire, Rating scales, interview and observation checklist were used to collect data for the study. The data collected was analyzed for Percentages and frequencies using Statistical Package for the Social Sciences (SPSS) version 23. The study's findings confirmed that in both schools; there were isolated science laboratory rooms, available laboratory apparatus and chemicals are stored in an unorganized way, there are no chemistry laboratory resources available adequately, chemistry teachers and students from grade 9 and 10 hardly use chemistry laboratories, demonstration method of experimentation is the most commonly used method and students laboratory performance assessment is based on the paper and pencil methods of assessment. It was also revealed that several teachers confronted problems when performing chemistry laboratory experiments due to inadequate availability of chemistry laboratory facilities, absence of well-trained laboratory assistant, lack of appropriate skills and training of chemistry teachers, and lack of important facilities including electricity and water to the laboratory rooms were some among the others. The study recommended that different stakeholders in education sector and other concerned bodies should support secondary schools in organizing and utilizing chemistry laboratory practical activities in both schools for the effective teaching and learning of the subject. *[African Journal of Chemical Education—AJCE 13(1), January 2023]*

INTRODUCTION

The knowledge and skills of the subject Chemistry is significant in various parts of life. It is a vital subject in different professions in the education system and in the rea-life situation of humankind. Especially, in the education system, including Medicine, Veterinary medicine, Nursing, Engineering and Biotechnology its role is significant. Moreover, it is also a crucial subject for the expansion of science and technology in any country. Science and technology play a central role in the modernization and growth of economic and social systems [1]. As claimed by Derkatch [2], the development of human resources in this area consequently has become a prominence in many developing countries.

Consequently, learning science, including chemistry, is an important part of primary and secondary education. In chemistry learning, laboratories have various benefits ranging from making learning actual to building foundation for science education in the succeeding levels of science learning [3]. In its nature Chemistry is an experimental science and its development and application demand experimental work [4] therefore, laboratory education plays crucial role in the education of chemistry for the growth of practical knowledge and skills of learners. In view of this fact, laboratory activity is considered to be the characteristic features of science education and particularly in chemistry education at all levels particularly, in secondary school science classes.

Particularly, Chemistry is a laboratory science and cannot be efficiently taught without a strong laboratory experience for students at any school levels. The identification, manipulation, and

general use of laboratory equipment are integral parts of the subject. Laboratory activities have long had a distinct and central role in the science curriculum as a means of making sense of the natural world. Practical chemistry, on the other hand, is an activity that involves students to either work independently or in a group in the laboratory or any place specifically assigned for carrying out an experiment and make an observation or manipulation of the real object and phenomenon. Conducting practical in chemistry is necessary bearing in mind that, the subject aims at understanding the chemical composition, nature, properties and transformation of matter [5].

The extent of adequacy of laboratory facilities for science teaching depends on the population of students in a particular school [6]. Furthermore, as mentioned by Takwate [7], the adequacy of laboratory facilities has been described to have a substantial outcome on the students' academic performance in chemistry. However, a study on the impact of the adequacy of laboratory facilities and academic performance in chemistry found that adequacy had a significant influence on students' academic performance in secondary school chemistry teaching [8].

Various research findings have shown that accessibility of teaching and learning resources make a significant contribution in performance in the Sciences. As Mwangi [9], mentioned most of the poorly performing schools spent less money on the purchase of teaching and learning resources. Masime & Masime [10] on the other hand, mentioned that there is a positive and significant relationship between students' achievement in physics and chemistry and the level of adequacy of laboratories, apparatus, chemicals and exposure of students to practical exercises. Furthermore, the

science laboratory has a direct effect on academic performance as per the instructional theory of learning interaction. As stated by Pareek [8], it is commonly supposed that constant practice leads to proficiency in what the learner learns during classroom instruction. Additionally, it is believed that the quality of teaching and learning science experiences depends on the scope of the adequacy of laboratory facilities in secondary schools and the teacher's effectiveness in the use of laboratory facilities with the aim of enabling and providing meaningful learning experiences in the learners. Besides, laboratory practices have been found to widen problem-solving abilities [11], intellectual maturity [4], scientific thinking [12], and practical skills [13].

Despite its significance of practical chemistry, developing countries are commonly characterized by a poor standard level of education which resulted from many factors, including limited budget to education, lack of trained and skilled manpower and inadequate facilities. The situation is more common in the developing countries where the inadequate amount of money allocated normally to education cannot provide to even 30% of what is required [14]. As it is well known, Chemistry without practical work is seen as a body of factual information and general laws, which conveyed nothing of lasting power to the mind [15]. The education and training policy of Ethiopia [16] states that science should be taught in a practical way. It discourages rote and memory learning. Fundamentally, the Ethiopian secondary and preparatory chemistry curriculum centers at facilitating students to solve real life problems and become independent and helpful citizens. In view of that, vital to the teaching-learning process in the secondary chemistry curriculum is practical work

directed towards mastery of scientific skills: process skills, manipulative skills and thinking skills. More distinctively, as stated by federal democratic republic of Ethiopia ministry of education [17], after completion of their upper secondary chemistry syllabi students are expected to use scientific methods in solving problems; and demonstrate an understanding of experimental skills, knowledge of laboratory procedure and scientific enquiry skills including observing, inferring, predicting, comparing and contrasting, communicating, analyzing, classifying, applying, theorizing, measuring; asking questions, developing hypotheses, performing and designing experiments, interpreting data, drawing conclusions, making generalizations and problem solving.

In this study, researchers will assess the availability of chemistry laboratories in schools, the resources available in the laboratories, extent of applying laboratory and its resources in teaching chemistry subject in 'Adet' and 'Debremewii' higher secondary school, Amhara region, Ethiopia. The school is selected on the basis of ease of access of transportation and on the basis of proximity to the researcher's residence.

Statement of the Problem

In schools, chemistry laboratory is the most proper place for students to learn how to research, organize, clarify and measure all the sciences. Most researchers believe that practical work is a significant activity in school science. At national level, in Ethiopian school students' achievements in chemistry subject has been low. This low achievement or performance of students in chemistry subject demonstrates that they are not meeting the expected knowledges, attitudes, and

skills as per indicated in the syllabus. Several research findings also revealed that there are aspects that can minimize students' achievements in chemistry subjects. As mentioned by Hastings & Bham [18], poor teaching methodology is one to be mentioned. Furthermore, Ndifon et. al., [19], revealed that allocation of low budget for provision of science laboratory resource is another factor for lower achievement of science subject in schools. Similarly, poor school administration and leadership, low teachers' commitment, insufficient schools' supervision [20], poor performance in practical activities [21], leads to students' low achievement in the subject chemistry.

Moreover, when the students are taught chemistry theoretically, without the practical aspects done in the laboratory, the students will not understand the abstract concepts of chemistry accurately. In order to teach the subject Chemistry practically, laboratory equipment and chemicals are vital. But they are hardly appropriately accessible due to their difficulty of obtainability and their expensive cost. As a result, many secondary schools could not conduct practical chemistry experiments as expected and stated in the textbooks. Additionally, the researchers' many years of teaching chemistry and close observation of secondary schools revealed that the current practice of chemistry laboratory organization and utilization is not satisfactory and to the expected standard as stated in chemistry curriculum. Moreover, assessment of the practice of organizing, designing, equipping, and utilizing chemistry laboratories is not conducted in these schools or there is very little if any, empirical data on the contributions of Chemistry laboratory which is a very vibrant necessity for teaching chemistry to the achievement levels in the subject at various levels. This research,

therefore, attempts to assess chemistry laboratory status and practices in ‘Adet’ and ‘Debremewii’ higher secondary school, Amhara Region, Ethiopia to make its support by filling this gap.

Objectives of the Study

The general objective of the study is to evaluate chemistry laboratory status and practices in ‘Adet’ and ‘Debremewii’ higher secondary school, Amhara Region, Ethiopia.

Specifically, the study desires;

i) To examine the extent of availability and adequacy of chemistry laboratory resources (laboratory room, equipment, apparatus, and chemicals) existing in ‘Adet’ and ‘Debremewii’ higher secondary school, Amhara Region, Ethiopia.
ii) To evaluate how chemistry laboratory apparatus and chemicals are stored in ‘Adet’ and ‘Debremewii’ higher secondary schools, Amhara Region, Ethiopia.
iii) To investigate how chemistry teachers and students use laboratories in the teaching and learning of chemistry in ‘Adet’ and ‘Debremewii’ higher secondary school, Amhara Region, Ethiopia.
iv) To diagnose the type of laboratory experimentation is commonly used (engaging students individually, doing experiments in parallel groups, demonstration, or others) and to point out why this/these methods are being used in these schools.

v) To survey how teachers assess students' laboratory performance and examine which Bloom's taxonomy of learning domains (cognitive, affective or psychomotor) components are measured in the schools under study.

vi) To point out problems confronted in using chemistry laboratories in the teaching and learning process of the subject chemistry in the schools under investigation.

Research Questions

This study is organized to answer the following questions:

i) Which chemistry laboratory resources are available adequately in the schools' chemistry laboratory?

ii) How are chemistry laboratory apparatus and chemicals stored in Adet' and 'Debremewii' higher secondary schools, Amhara Region, Ethiopia?

iii) How do chemistry teachers and students of grades 9 and 10 use chemistry laboratories in the teaching and learning process of the subject chemistry in the schools?

iv) What type of laboratory experimentation is commonly used (engaging students individually, doing experiments in parallel groups, demonstration, or others) in these schools and why?

v) How do teachers assess students' laboratory performance and which Bloom's taxonomy of learning domains (cognitive, affective or psychomotor) components are measured?

vi) What are the problems confronted in using chemistry laboratories in the teaching and learning process of the subject chemistry of grades 9 and 10 in the schools under the study?

MATERIALS AND METHODS

The study context

In Ethiopia, secondary schools' chemistry is one of the subjects being given to students. In the secondary school chemistry curriculum document, the subject chemistry is expected to be delivered both theoretically and using students' hand-on activities. In most secondary schools of Ethiopia, chemistry laboratories are inadequately, and poorly organized. Hence, the practice, utilization and challenges of using chemistry laboratory is highly questionable. Moreover, due to absence of proper utilization of practical teaching of the subject chemistry, students' achievement in chemistry subject in secondary school is believed to be poor. Therefore, the study is aimed to assess the status and practices of chemistry laboratory organization and utilization in 'Adet' and 'Debremewii' Higher Secondary schools, Amhara Region, Ethiopia.

Research Method

In the study, A mixed research approach specifically, descriptive survey technique was employed. Mixed research approach was employed as the advantage arose in using both quantitative and qualitative designs. As Creswell and Zhang [22]**,** noted though the basis for employing mixed designs is varied, they can be generally described as methods to expand the scope or breadth of

research to counterbalance the weaknesses of either approach alone. Moreover, as mentioned by Mugenda and Mugenda [23], a survey design is employed to collect data from members of a population in order to determine the existing status of that population with respect to one or more variables. The study used survey design was adopted since it involved collecting data in order to answer questions regarding the current status of focus of the study.

Furthermore, survey design permits the use of numerous instruments including questionnaires, an interview schedule and an observation schedule. The study used questionnaires, an interview schedule and an observation schedule to obtain both qualitative and quantitative data from students, teachers, heads of science departments and laboratory technicians regarding the practice and utilization of Chemistry laboratories in 'Adet' and 'Debremewii' Higher Secondary schools, Amhara Region, Ethiopia.

Research design

In order to conduct the present study, triangulation design: most common and well-known approach to mixing methods [24], whose purpose is "to obtain different but complementary data on the same topic" to best understand the research problem was applied.

Sample and Sampling Technique

In the case of this specific research, purposive sampling was employed to select science teachers in these schools because they are the ones who are responsible in teaching science subjects. Heads of departments were selected for virtue of their position as they directly related to the use of

laboratory. Heads of schools were selected due to their position as they are in charge of these schools and whose administrative functions were to ensure that the implementation curriculum in their schools take place. According to Kombo & Tromp [25]**,** purposive sampling is the procedure where the researcher purposively targets groups of people believed to be reliable for the study.

In the case of this specific research, 'Adet' and 'Debremewii' higher secondary schools, Amhara Region, Ethiopia was selected, and grades 9 and 10 chemistry subject was the target of the study.

The population for the study was 22 (Male =18 and Female= 4) and 4 (Male =4 and Female= 0) chemistry teachers, department heads (one from each school), directors (one director and one vice director from each school), and 60 (Male =32 Female= 28) and 28 (Male =16 and Female= 12) students from 'Adet' and 'Debremewii secondary schools of grades 9 and 10 respectively. Hence, from both schools 26 chemistry teachers (Male = 22 and Female = 4), two department heads (both males), two directors (both males), two vice directors (both males) and 88 students (Male = 48 and Female= 30) were participated in providing data for the study. In the case of taking samples from students simple random sampling was used. In other cases, there was no sampling because the population was considerable for the study.

Table 1: Population and Sample Size of Respondents

Selected school	Chemistry Teachers			Department heads	Directors	Vice Directors	Students			Total
	Male	Female	Total				Male	Female	Total	
'Adet' secondary school	18	4	22	1 (Male)	1 (Male)	1 (Male)	32	28	60	**85**
Debremewii Secondary school	4	0	4	1 (Male)	1 (Male)	1 (Male)	16	12	28	**35**
Total sample size	22	4	**26**	**2**	**2**	**2**	48	40	**88**	**120**

In this study, in both schools all chemistry teachers, all directors and vice directors are taken as a sample. But students from both schools were determined and representative samples were taken to proceed with the study.

Data Collection Techniques and Instrumentations

Since the methodology employed in the research is mixed methods, both quantitative and qualitative data are gathered. Based on the methodology and the design selected, the quantitative data are collected by survey questionnaire & rating scale design and the qualitative data are collected by interview & observation checklist guide in a sequential model. Thus, survey questionnaire, rating scale design, interview, and observation checklist techniques was be employed.

The instrument used was on a five-point rating scale with numerical values of strongly agree (SA (5), Agree (A (4), neither agree nor disagree (NAD (3), disagree (DA (2) and strongly disagree

(SD (1). The instrument was validated by experts or teachers in chemistry teaching and measurement and evaluation. The questionnaire was distributed to the chemistry teachers. There was 100% return and the data gathered were analyzed using frequency percentage.

The instrument for data collection was both structured and unstructured questionnaire. The questionnaires were divided into two sections. The first section centered on the personal data of the respondents, while section-II is established based on the research questions. The items in section-II of the questionnaire were structured on an adapted five-point Likert scale. The research instruments were exposed to validation by two chemistry teachers and experts. Their suggestions given was included in the final copy of the instrument. The data collected were analyzed and interpreted using frequency distribution to answer the research questions. This particular research used various instruments, including questionnaires, observation schedule, rating scales and interview schedule.

Validity and Reliability of Research Instruments

For the purpose of discovering that the tools measured what they were intended to measure, the researcher employed the use of experts who were qualified in chemistry and skilled in measurement and evaluation. The expert's judgment helped to improve the content validity of research instruments.

Data Analysis

Data was collected on variables such as resources available and their adequacy, availability of laboratory technicians, activities done in the laboratory, and teachers and students' participation

in the laboratory methods of teaching, and challenges faced in using chemistry laboratories in both schools Adet' and 'Debremewii' higher secondary schools, Amhara Region, Ethiopia.

For data analysis, both quantitative and qualitative methods to analyze various data sets acquired for this study was utilized and both quantitative and qualitative data are analyzed separately and assorted at the discussion stage. Moreover, the data analysis started from the quantitative data collected by questionnaire and rating scale. Finally, the qualitative results gathered by interview and observation checklist was analyzed via narration following the themes was formed considering the nature of the evidence.

The data which were found from diverse sources were systematized in a way suitable for responding to the research questions. The researcher used SPSS version 23 software to calculate frequency counts and percentages to analyze the data from close-ended questions. The findings were related to each research question were examined and discussed in relation to the review literature. Descriptive statistics namely percentages, and frequency distribution were used to describe the data and conclusions were drawn on the basis of the analyzed data and recommendations are made based on the conclusions.

DATA PRESENTATION AND ANALYSIS

For this particular study, both quantitative and qualitative data were collected. The data gathered were presented and analyzed successively. Initial analysis of quantitative data was followed

by qualitative interview analysis. For convenience, the summary of the quantitative data gathered from each sample textbook is presented in a table.

Demographic Background

Demographic Characteristics of Chemistry Teachers

Table 2 below describes information about respondents' characteristics related to sex, qualification, and experiences.

Table 2: Demographic characteristics of chemistry teachers

Categories		Frequency	Percent
Schools	'Adet' secondary school	1	50
	'Debremewii' secondary school	1	50
	Total	2	100
Sex	Male	22	84.6
	Female	4	15.4
	Total	26	100
Qualifications	B.Sc./BA/B.Ed	25	96.2
	M.Sc./MA/M.Ed	1	3.8
	Total	26	100
Experiences	Less than 5 years	0	0
	5 – 10 years	5	19.2
	Greater than 10 years	21	80.8
	Total	26	100

The primary aim of this study was to assess the practice, organization, utilization, and problems related to the secondary school's chemistry laboratory in 'Adet' and 'Debremewii' secondary schools. Various tools of data gathering instruments were employed to obtain reliable evidence on the study area. The findings were explained under the following sub sections.

RESULTS

The result of this investigation is presented below based on the research questions of the study.

Research question one:

Adequate availability of Chemistry Laboratories resources

Chemistry teachers, department heads, directors, and students from grades 9 and 10 were given a five-point Likert scale and their responses are analyzed below.

Table 3: Frequency and Percentage of Adequate availability of chemistry laboratory resources in 'Adet' and 'Debremewii' secondary schools

S/N	Schools	Laboratory Resources	Respondent (N)	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Decision
				Freq	%	Freq	%	Freq.	%	Freq	%	Freq.	%	
1.	'Adet' secondary school	Laboratory room avail.	82	0	**0**	0	**0**	1	**1.2**	1	**1.2**	80	**97.6**	**Available**
2.		Adequate chemicals available	82	78	**95.1**	3	**3.7**	1	**1.2**	0	**0**	0	**0**	**Not Available**
3.		Adequate apparatuses available	82	76	**92.7**	4	**4.9**	2	**2.4**	0	**0**	0	**0**	**Not Available**
4.		Adequate laboratory furnitures available	82	0	**0**	0	**0**	0	**0**	32	**39.1**	50	**60.9**	**Available**
5.		Electricity supply available	82	0	**0**	0	**0**	0	**0**	55	**67.1**	27	**32.9**	**Available**
6.		Water supply available	82	70	**87.5**	10	**12**	2	**2.5**	0	**0**	0	**0**	**Not Available**
1.	'Debremewi' secondary school	Laboratory room avail.	32	0	**0**	0	**0**	2	**6.25**	10	**31.25**	20	**62.5**	**Available**
2.		Adequate chemicals available	32	30	**93.75**	2	**6.25**	0	**0**	0	**0**	0	**0**	**Not Available**
3.		Adequate apparatuses available	32	29	**90.6**	3	**9.4**	0	**0**	0	**0**	0	**0**	**Not Available**
4.		Adequate laboratory furnitures available	32	0	**0**	0	**0**	4	**12.5**	21	**65.6**	7	**21.8**	**Available**
5.		Electricity supply available	32	29	**90.6**	0	**0**	3	**9.4**	0	**0**	0	**0**	**Not Available**
6.		Water supply available	32	32	**100**	0	**0**	0	**0**	0	**0**	0	**0**	**Not Available**

The data in table 3 displays that 81 (98.8%) and 30 (93.75%) of respondents have confirmed as ‘Adet’ and ‘Deberemewii’ secondary school have laboratory rooms or buildings respectively.

The researcher also conducted an observation to discover the number of laboratory buildings in each school and how they are prearranged for several uses. The surveying of chemistry laboratory also revealed that one chemistry laboratory room occurs in each school under investigation. Furthermore, in regards to the availability of basic chemicals and apparatuses to conduct grades 9 and 10 chemistry practical activities, 78 (95.1%) and 30 (93.75%) of respondents confirmed that there are no adequate chemicals in both secondary schools of ‘Adet’ and ‘Deberemewii’ respectively. Besides 76 (92.7%) and 29 (90.6%) respondents also indicated ‘Adet’ and ‘Deberemewii’ secondary schools don’t have adequate chemistry laboratory chemicals for the level of grades 9 and 10 chemistry correspondingly.

As described in the methodology section of this study, to strengthen the quantitative data collected sample students, chemistry department heads, and school directors were interviewed to collect qualitative data. The participants of the interview have also expressed as both schools don’t have adequate chemistry laboratory chemicals and apparatuses to run practical chemistry activities in the schools’ laboratory. They additionally, said that:

> *The chemistry department, chemistry teachers, and students are continually requesting the schools to have adequate laboratory resources including chemicals, apparatus and materials and intern schools are frequently asking concerned officials to make them avail adequately. But, for years the problem continues to exist and teachers and schools are forced to teach the subject chemistry on theoretical basis only. (Interviewee 1, May 6, 2022).*

The researcher's observation also approves the ideas given by the interviewee and the quantitative data presented above in table 3.

The complete analysis of the data on availability of laboratory and laboratory resources illustrates that both 'Adet' and 'Debremewii' secondary schools have chemistry laboratories as buildings. Moreover, the findings displayed that there was no adequate chemicals and apparatuses in the schools. From this it is known that teaching the subject chemistry using experimentation is not being carried out. But it is believed that a laboratory should be properly equipped if it is to serve its purpose [26].

The table also illustrates the availability of chemistry laboratory furnitures, electricity and water supplies in the school laboratories. The data obtained from the respondents (Chemistry teachers, department heads, directors, and students from grades 9 and 10) clearly confirmed that both 'Adet' and 'Debremeweii' secondary schools have laboratory furnitures including desks, chemical store shelfs, blackboards, chairs, and tables as the data from respondents 82 (100%) and 28 (87.4%) revealed respectively. In regard to, the supply of electricity to the chemistry laboratory 82 (100%) of respondents from 'Adet' secondary schools mentioned as there is an electricity supply and in contrary 29 (90.6%) of respondents from 'Debremewii' secondary school revealed that the chemistry laboratory in the school doesn't have an electric supply. Similarly, respondents stated that the water supply is the same as that of water.

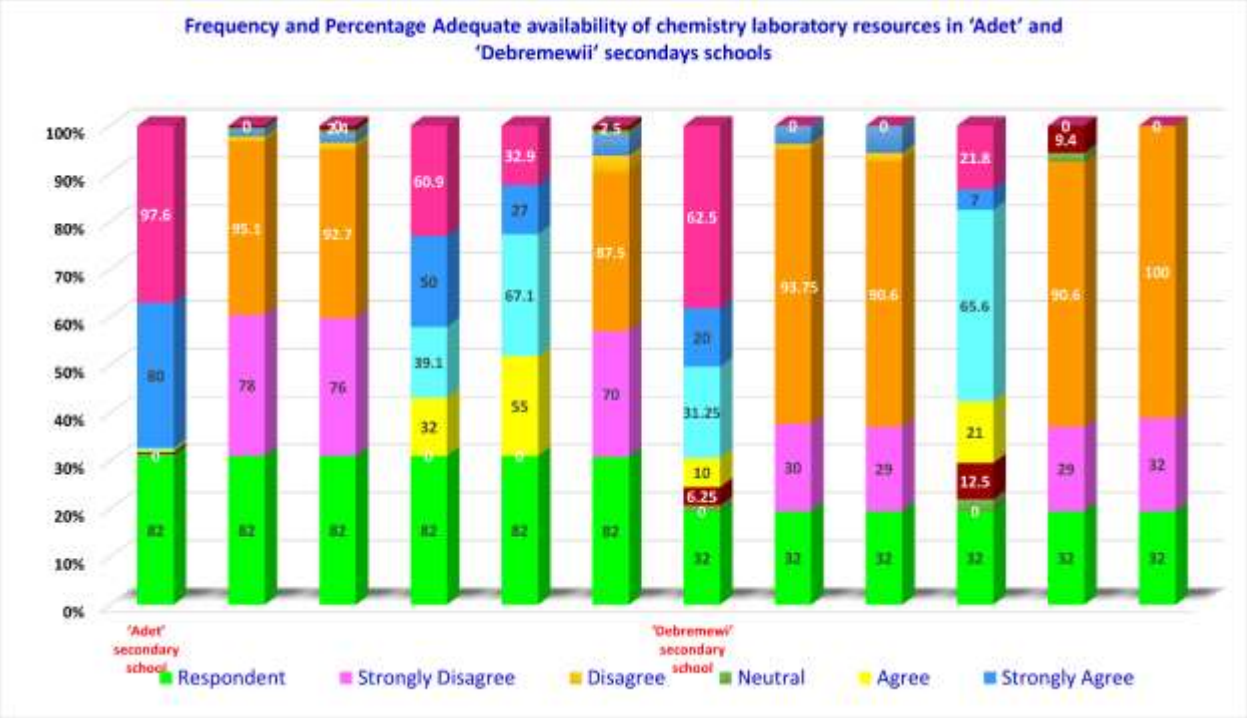

Figure 1. Frequency and Percentage Adequate availability of chemistry laboratory resources in 'Adet' and 'Debremewii' secondary schools.

The finding of this study showed that there are schools within Amhara Region, Ethiopia, still today that do not have chemistry laboratories in secondary schools. In one of these schools, 'Debremewii' secondary school there is no a single chemistry laboratory activity shown to students. But, very little practical work, mostly of the form of teacher demonstration was said to be taking place in 'Adet' secondary school.

Hence, it can be deduced that teaching chemistry with inadequate laboratory or in the absence of laboratory supported teaching is one of the key causes of students' poor achievement in chemistry in Amhara Region, Ethiopia. The finding of this study in in agreement with several other research findings. Among these, Millar [27], described that schools with no laboratories were poor with human and material resources and are likely to affect student's achievement in Chemistry. Furthermore, as stated by Lewis [28]**,** engaging students in practical activity boosts learning by allowing learners to share ideas and experiences within their groups.

Research question two:

The way Chemistry laboratory apparatus and chemicals stored in schools

Chemistry teachers (Adet = 22, Debremewii = 4), Department heads (one from each school), Directors (one from each), and Vice directors (one from each) were subjected to respond the techniques used to store laboratory chemicals and apparatuses that are available in the school.

Table 4: Frequency and Percentage of methods of chemicals and apparatuses arrangement in the laboratory in 'Adet' and 'Debremewii' secondary schools

Schools	Items/Determinant factor	Respondents (N)	Organized based on scientific ways		Organized but not in a scientific way		Stored in a random way		Decision
			Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**	
'Debremewii' Secondary school	Approaches in which the available chemicals are stored	7	0	0	6	85.7	1	14.3	organized but not in a scientific
	Methods in which the available apparatuses are	7	0	0	7	100	0	0	organized but not in a scientific
'Adet' Secondary school	Approaches in which the available chemicals are stored	25	0	0	23	92	2	8	organized but not in a scientific
	Methods in which the available apparatuses are stored	25	0	0	24	96	1	4	organized but not in a scientific way

However, there are no adequate chemistry laboratory chemicals and apparatuses in both schools, under this research question the approaches used to store already existing chemicals and apparatuses were studied. Findings from the above table 4 shows that in both schools the technique used to store chemicals and apparatuses were organized but the organization is not on the basis of rules and regulations of chemicals and apparatus placement.

The observation made by the researcher also like the conclusion of the above table. Specifically, the researcher observed that improper labelling of chemicals, wrong storage of reactive

chemicals, for instance acids are stored closer to bases in Adet secondary school. Additionally, the researcher observed that glassware sets are placed with metals hence, the glassware can easily get broken.

Therefore, it can be deduced that the already existing chemicals and apparatuses were organized or isolated, but the organization was not based on the rules and regulations of apparatuses and chemicals storage.

Research question three:

Chemistry teachers and students' extent of utilization chemistry laboratories for teaching and learning the subject chemistry in the schools

Chemistry department heads, teachers, directors, and vice directors, from each school were questioned to respond questionnaire, fill the rating scale, and conduct an interview with the researcher on extent of utilization chemistry laboratories and type of experimentation used in teaching chemistry in 'Adet' and 'Debremewii' secondary schools.

Table 5: Frequency and Percentage of extent of utilization chemistry laboratories and type of experimentation used in teaching chemistry in 'Adet' and 'Debremewii' secondary schools

S/N	Scho	Items	Resp on(N	Responses	Calculations		Conclusion
					Frequ.	%	
1.	'Debremewii' Secondary School	Laboratory session time table is prepared and used	7	Yes	2	28.6	Laboratory session time table is not prepared and used
				No	5	71.4	
2.		How often do you use chemistry laboratory for teaching chemistry	7	Once in a week	0	0	Laboratory is used for teaching once in a semester
				At the end of each unit	0	0	
				Once in a semester	7	100	
				Once in a year	0	0	
				Not at all	0	0	
3.		What method/strategy do you usually, use in teaching chemistry in the laboratory	7	Students' independent activity	0	0	Demonstration methods of teaching is the most commonly used lab. Teaching method
				Small group activity	0	0	
				Demonstration	7	100	
				Large group activity	0	0	
				No laboratory session is conducted	0	0	
1.	Adet' Secondary School	Laboratory session time table is prepared and used	25	Yes	0	0	Laboratory session time table is not prepared and used
				No	25	100	
2.		How often do you use chemistry laboratory for teaching chemistry	25	Once in a week	0	0	Chemistry laboratory is not used at all.
				At the end of each unit	0	0	
				Once in a semester	0	0	
				Once in a year	0	0	
				Not at all	25	100	
3.		What method/strategy do you usually, use in teaching chemistry in the laboratory	25	Students' independent activity	0	0	Chemistry laboratory is not used at all.
				Small group activity	0	0	
				Demonstration	0	0	
				Large group activity	0	0	
				No laboratory session is conducted	25	100	

From table 5, it is observed that the percentage of absence of laboratory session timetable is larger. 71.4 % of respondents from 'Debremewii' secondary school and 100% of the other

respondents from ‘Adet’ secondary school confirmed that there is no laboratory session time table prepared and used in the school. In regards to the extent of using chemistry laboratory for practical teaching of students, 100% of respondents described as they used the school laboratory once in a semester and 100% of the other respondents mentioned as they never use the chemistry laboratory at all for practical teaching of the subject chemistry in ‘Debremewii’ and ‘Adet’ secondary schools respectively.

The interview made with chemistry department heads of the schools, and the directors and vice directors also in agreement with the above data and findings. Interviewees revealed that the departments in both schools don’t have already scheduled timetable. Additionally, interviewees from ‘Adet’ secondary school mentioned that chemistry teachers plan their own time and brings students to the laboratory once in a semester. Similarly, the interviewees from ‘Debremewii’ secondary schools declared that chemistry teachers totally were not using the school chemistry laboratory as there is lack of necessary chemicals and apparatuses in the school.

In addition to the above result, the researcher observations also assured that in the two schools timetable for conducting chemistry laboratory sessions were not arranged and in ‘Adet’ secondary school chemistry teachers document indicated as they have conducted one laboratory session (2 hours in this specific case) for grades 9 and 10 students. The researcher observation of

'Debremewii' secondary verified as chemistry teachers were not using the chemistry laboratory for the whole academic year.

It can therefore be concluded that in both secondary schools, laboratory session time table is not prepared and utilized for teaching chemistry using numerous experiments and hands-on activities. Moreover, the extent in which chemistry teachers use experimental methods of teaching the subject chemistry is very low. As mentioned by Muchai & Twoli [29], learning in any science laboratory is a hands-on experience and in a laboratory setting, students use laboratory chemicals, reagents, and various apparatus to operate materials, gather data, make inferences and interconnect the results and their findings.

Research question four:

Type of laboratory experimentation is commonly used in schools

Through the researcher was planned to conduct the actual chemistry teaching sessions in both schools, teachers in 'Debremewii' secondary school already revealed that they were not teaching chemistry using the laboratory and chemistry teachers in' Adet' secondary schools informed the researcher as they don't have sessions recently. Therefore, the researcher asked theses chemistry teachers to explain what method/strategy do they usually, use in teaching chemistry in the laboratory? They verified as demonstration method of teaching is the only method used to teach chemistry in their teaching. They also elucidated the reason why they were depending on this method

and mentioned that absence of adequate laboratory facilities is one among others. Additionally, they described that this method helps them to save time: two or three practical activities can be conducted in short time.

The findings displayed in Table 5 above also showed that almost all (100%) of 'Adet' and 'Debremewii' secondary schools respondents reveled that the method or strategy employed to teach chemistry practically is demonstration and no laboratory sessions was conducted respectively in these schools.

In conclusion, the findings therefore showed that there was no any laboratory-based teaching of the subject chemistry in 'Debremewii' secondary school and even in 'Adet' secondary school where there was a laboratory session conducted once in a semester demonstration was the commonly employed method. As mentioned by the school chemistry teachers, inadequate chemistry laboratory facilities and the advantage of demonstration method to conduct two or three practical activities within short time were the reasons stated.

The involvement of students, the teacher or both in the laboratory activity

The researcher's critical observation, the data obtained from Table 5 above, and interviewees' explanation proved that in 'Debremewii' secondary school there was no learners' engagements in the laboratory activities as there was no practical activity conducted in the school. But, in 'Adet' secondary school as mentioned above, the various data collected indicated that

demonstration is the typical method used in laboratory teaching in the school. In employing teacher demonstrated laboratory method, teachers reveal the real experiments or scientific investigations to enlighten science lessons to the class using limited set of laboratory equipment and materials.

Hence, in the case of this particular study students were not engaged actively in laboratory experimentation in both schools. In the case of 'Adet' secondary school teachers are highly involved in the preparation, conducting the actual experiment to be demonstrated and students participated in an observation of teacher's demonstration task.

Research question five:

Students' laboratory performance assessment in relation to Bloom's taxonomy of learning domains (cognitive, affective or psychomotor) components.

Table 6: Frequency and Percentage of students' laboratory performance assessment in relation to Bloom's taxonomy of learning domains in chemistry laboratory teaching

S/N	School	Items	Respon (N)	Responses	Calculations		Conclusion
					Frequ.	%	
1	' Dakmanyii Secondary School	The teacher identifies the cognitive, affective, and psychomotor domains of the laboratory activity before conducting the laboratory session	7	Yes	1	**14.3**	
				No	6	**85.7**	
2		Students' laboratory performance is assessed using rubric designed at department level.	7	Yes	0	**0**	
				No	7	**100**	
3		Students' different laboratory performance (cognitive, affective, and psychomotor domains) are assessed separately as per the objectives of the task.	7	Yes	0	**0**	
				No	7	**100**	
4		Students' laboratory performance is assessed using paper and pencil exams separately from the theoretical aspects.	7	Yes	1	**14.3**	
				No	6	**85.7**	
5		Students' Laboratory performance is not separately assessed in the school.	7	Yes	7	**100**	
				No	0	**0**	
1.	' Adet' Secondary School	The teacher identifies the cognitive, affective, and psychomotor domains of the laboratory activity before conducting the laboratory session	25	Yes	0	**0**	
				No	25	**100**	
2.		Students' laboratory performance is assessed using rubric designed at department level.	25	Yes	1	**4**	
				No	24	**96**	
3.		Students' different laboratory performance (cognitive, affective, and psychomotor domains) are assessed separately as per the objectives of the task.	25	Yes	0	**0**	
				No	25	**100**	
4.		Students' laboratory performance is assessed using paper and pencil exams.	25	Yes	2	**8**	
				No	23	**92**	
5.		Students' Laboratory performance is not separately assessed in the school	25	Yes	24	**96**	
				No	1	**4**	

The results in Table 6 show that in both secondary schools, ‘Adet’ secondary school (100%) and ‘Debremewii’ secondary school (85.7%) chemistry teachers were not identifying the cognitive, affective, and psychomotor domains of the laboratory activities included in grades 9 and 10 students chemistry textbooks before conducting the laboratory session. Both chemistry teachers in ‘Adet’ (96%) and ‘Debremewii’ (100%) secondary school teachers were not used students’ laboratory assessment rubric to assess the laboratory performance of students in chemistry laboratory. Additionally, in both schools (100%) chemistry teachers were not measuring students’ diverse laboratory performance (cognitive, affective, and psychomotor) domains as per the objectives of each of specific tasks. In the same way, in both schools in ‘Adet’ (96%) and ‘Debremewii’ (100%) secondary schools the students’ laboratory performance was not distinctly assessed.

Moreover, the result of interview revealed that students’ laboratory performance was not practiced in both schools. The respondents from both schools (department heads, vice directors and the director of the schools) mentioned that chemistry teachers in both schools were not acquainted with the concept of performance assessment. They also added that the extent of using chemistry laboratory is either nil or once in a semester in the academic year.

It can therefore be concluded that in ‘Adet’ and ‘Debremewii’ secondary schools the students’ chemistry laboratory performance was not assessed. But it is generally known that by

engaging students in authentic laboratory performance assessments, opportunities are provided for them to construct meaning and to internalize new ideas and concepts.

Research question six:

Problems confronted in using chemistry laboratories in the teaching and learning the subject chemistry in the schools

This section of the analysis was to examine the understandings of chemistry teachers, department heads, directors, and vice directors on the aspects that influence the effective utilization of chemistry laboratory activities in teaching the subject chemistry the secondary schools under investigation. Respondents were allowed to select more than one options when they thought that the stated description is problem confronted in using chemistry laboratory. Therefore, the following items have been recognized in the study and the answers of chemistry teachers, department heads, directors, and vice directors were presented, analyzed, and interpreted below.

Table 7. Problems confronted in using chemistry laboratories

S/N	Item descriptions	Participants	Respondents (N=32)	Percentages	Remarks
1.	Teacher's lack of skills to conduct laboratory activity	✓ Total Chemistry teachers from both schools = 26 ✓ Chemistry department heads = 2	20	**62.5**	
2.	Lack of time table to run laboratory activities		5	15.6	
3.	Lack of adequate chemicals and apparatus		31	**96.9**	
4.	Lack of students' interest and motivation		4	12.5	
5.	Lack of electricity supply to the laboratory rooms		28	**87.5**	
6.	Lack of water supply to the laboratory.		25	**78.1**	

7.	Absence of appropriate trained laboratory technician or attendant	✓ Directors from both schools = 2 ✓ Vice directors from both schools = 2	27	**84.4**	
8.	Absence of teachers' commitment		2	6.3	

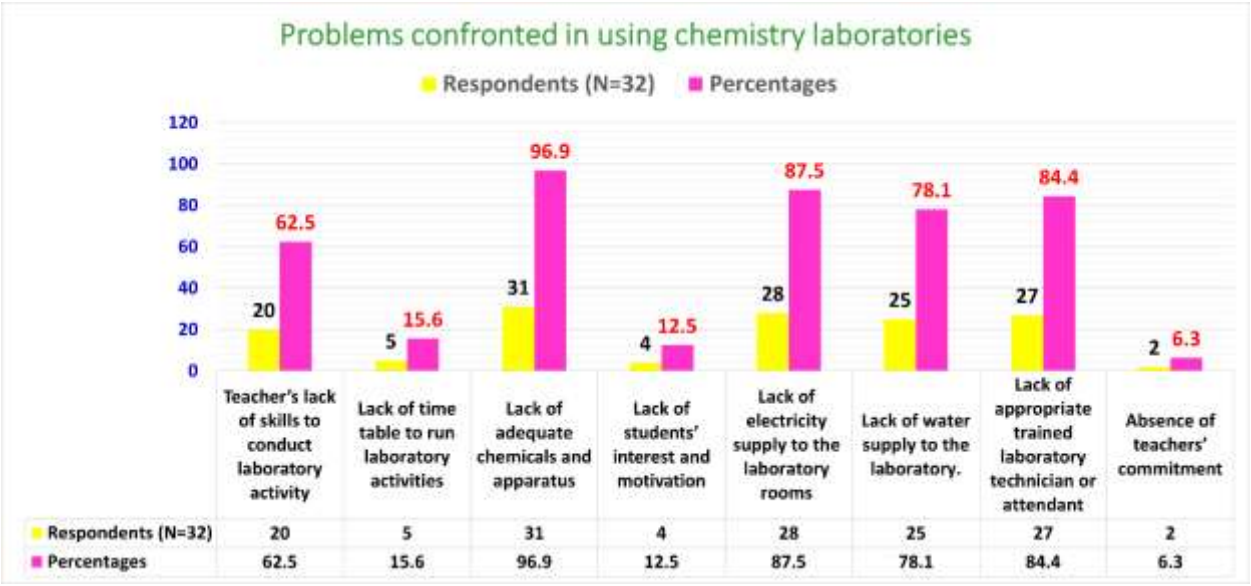

Figure 3: Problems confronted in using chemistry laboratories

In figure 3: the response indicates that lack of adequate chemicals and apparatus (96.9%), absence of appropriate trained laboratory technician or attendant (84.4%), teacher's lack of skills to conduct laboratory activity (62.5%), and lack of electricity and water supply to the laboratory rooms (87.5 %) and (78.1%) respectively are the identified problems that hindered the effective chemistry laboratory usage in both schools.

Additionally, in replying to interview and open-ended questions, as replied by respondents, there were several problems that faced in effective utilization of practical activities in both schools.

The crucial once was inadequate availability of chemistry laboratory facilities in the schools, absence of well-trained laboratory assistant in schools, lack of appropriate skills and training of chemistry teachers in both schools, and lack of important facilities for instance, electricity, water to the laboratory rooms were some among the others.

Consequently, it can be concluded that lack of adequate chemicals and apparatus, absence of proper trained laboratory technician, teacher's lack of skills in laboratory organization, utilization, and applying different teaching strategies in laboratory activity, and lack of electricity and water supply to the laboratory rooms are the utmost difficulties of 'Adet' and 'Debremewii' secondary schools, Amhara Region, Ethiopia.

DISCUSSIONS

In this particular study, the status and practices of chemistry laboratory organization and utilization in 'Adet' and 'Debremewii' Secondary schools, Amhara Region, Ethiopia was studied. On the first research question on this study, it was aimed to examine the adequate availability of Chemistry Laboratories resources in both schools. The fundamental finding of this study is that, in the context of the school's chemistry laboratory chemicals and apparatuses that are relevant to teach grades 9 and 10 chemistry were not adequately available in both schools. This finding is consistent with the findings of previous research: Barrow`s [30], Onipede [31], and Ihuarulam [32], who in their distinct studies stated that science education is faced with the challenges of lack of resources

with majority of the secondary schools having no real laboratory. Additionally, Akpan [33], strongly believed that scarcities of laboratory facilities could have thoughtful implications on the learning and academic achievement of students. Moreover, Nkwocha [34], who opined, that without laboratory facilities teaching and learning of science will not take place effectively.

Similarly, Anyadiegwu [35], mentioned that there is lack of appropriate laboratory facilities that are suitable and suitable for Nigerian schools. Moreover, Niyitanga et al. [36], stated that lack of adequate funding in education is a barrier to availability of laboratory facilities in public secondary school and unavailability of laboratory facilities creates difficulty to science teachers' real delivery of concepts. Besides, the findings of Muse [35], revealed that unavailability of teaching facilities affects actual delivery of science, technology and mathematics in general.

According to Anyadiegwu [3], adequate laboratory instructional facilities are required in schools to minimize the challenges of science teachers in schools. In the same way, Etiubon [38], observed that the fulfillment of laboratory facilities in schools marks an improved efficiency of the educational development and results in improved proficiency through boosted human capacity as this facilitates acquisition of basic knowledge and skills for laboratory experiment and lifelong development. Similarly, the findings of Eze [39], supported the above findings when he described those physical facilities such as classroom, laboratories are abysmally inadequate, unmaintained and lack requisite apparatus and equipment. The presence of chemicals and equipment for teaching and learning of chemistry practical may not be enough to bring about better performance of the students

without a competent chemistry teacher. According to Ali [14], these materials will hardly be helpful if the teacher does not use them effectively and efficiently.

Secondly, a research question was stated to determine the way Chemistry laboratory apparatus and chemicals stored in the schools under investigation. The findings of the study revealed that chemicals and apparatuses were organized or isolated, but the organization was not based on the scientific rules of chemicals and apparatus storage. This finding is similar to the idea or practice of the University of Utah's environmental Health and Safety department explained that alphabetization can be a helpful way to organize chemicals for easy access, but that it should not be used until after separating chemicals into categories.

The third research question for this study was to determine Chemistry teachers and students' extent of utilization chemistry laboratories for teaching and learning the subject chemistry in the schools. The findings of the study confirmed that the extent of these schools' utilization of the laboratory activities is either nil or once in a semester for grades 9 and 10. This finding is in line with Ochwada [40], who specified that learning is a complex task that comprises interaction of students‟ inspiration, physical facilities, teaching resources, skills of teaching and curriculum demands.

The fourth research questions were intended to examine the type of laboratory experimentation is commonly used in schools. The findings showed that there was no any laboratory-based teaching of the subject chemistry in 'Debremewii' secondary school and in 'Adet' secondary

school where teachers used the laboratory once in a semester demonstration was the commonly employed method. This finding is similar to the findings of the previous studies: Harty and Al-Faled [41]; Knox [42]; Cooke [43]; Carptenter [44]; who studied about the role and effect of demonstrations in both high school and college instruction and they were thought to be affective aids in increasing student's conceptual understanding in a summary of early opinion literature [45].

The fifth research objective was planned to evaluate the engagement of students', teachers' or both students' and teachers in the laboratory tasks. The finding of this study proved that students were not engaged actively in laboratory experimentation in both schools. Experiments are part and parcel of the current competence-based curriculum. This finding is in agreement with other previous findings for instance according to Omosewo [46] claimed that understanding of the science and technology procedures is achieved through laboratory tasks. Moreover, he stated that laboratory activities inspire active participation of learners and develops critical thinking. Laboratories provide concrete experiences to substantiate the theoretical aspect that has been taught. Similarly, Tilya [47] mentioned that, teaching by the use of laboratory helps the development of cognitive abilities. Additionally, students are expected to be actively involved in the learning process if they have to make ideas concrete and thoughts presented during the lesson and this is expected for any practical lesson to be significant [27].

The next research objective was intended to examine how Students' laboratory performance is assessed in relation to Bloom's taxonomy of learning domains (cognitive, affective,

or psychomotor) components. The findings clearly showed that in the schools under investigation students' laboratory performances were not assessed. The finding of the previous researches also showed that students' laboratory performance assessment was a challenge in most secondary and tertiary levels. The domains of learning as described by Bloom's Taxonomy are the cognitive, affective and psychomotor [48]. Relative to the laboratory performance assessment of students, the research finding is in agreement with that of Twoli [49] who stated that assessment is an important aspect of any educational programme. This assertion is supported by Ayot [50] and Breener [51] who both stressed that the techniques and frequency of assessment profoundly affect the content of the curriculum, how it is taught and ultimately performance. Performance tasks, in addition to assessing student abilities, offer students authentic practices through which understanding can be constructed and therefore work as instructional tools to enhance student learning [52].

Last research objectives were intended to identify the problems faced in using chemistry laboratories in the teaching and learning of chemistry in the schools. The finding revealed that, the chemistry teachers, department heads, vice directors sampled for this study agreed that the factors inhibiting effective utilization of chemistry laboratory include: inadequate availability of chemistry laboratory facilities, absence of well-trained laboratory assistant, lack of appropriate skills and training of chemistry teachers, and lack of important facilities including electricity and water to the laboratory rooms were some among the others. This finding is in line with the finding of Samwel

[53] who similarly recognized the above influences as challenges influencing actual utilization of chemistry laboratory for teaching chemistry.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Below are the main findings of this study based on the research questions.

a) The study confirmed that chemicals and apparatuses in both ‘’Adet’ and ‘Debremewii’ secondary schools’ chemistry laboratory were not adequately available.
b) The findings of the study realized that chemicals and apparatuses were isolated separately but the organization was not based on the scientific rules of chemicals and apparatus storage.
c) The study verified that both schools were not employing chemistry laboratory for teaching chemistry practically.
d) The findings showed that ‘Adet’ secondary school teachers were used the laboratory once in a semester and in this particular case demonstration was the commonly employed method.
e) The study verified that students were not engaged in laboratory activity in learning the subject chemistry in both secondary schools.
f) The findings of the study showed that students’ laboratory performances were not assessed in both schools.
g) The study confirmed that, inadequate availability of chemistry laboratory facilities, absence

of well-trained laboratory technician, lack of appropriate skills and training of chemistry teachers, and lack of electricity and water facilities to the laboratory rooms were identified challenges.

Conclusions

The enhancement of secondary school chemistry laboratory is a serious problem that needs to be addressed very recently. The current study investigated the practices, utilization and challenges of sampled secondary schools of Amhara region, Ethiopia. The finding of the study has provided the basis for the researcher to conclude that laboratory facilities are highly inadequate, falling short of a standard or norm for practical chemistry instruction. Therefore, in both schools' chemistry experiments were not being conducted. Hence, concerned stakeholders should give due attention and solve this serious problem.

Furthermore, the few chemicals and apparatuses available in the school were not organized using scientific ways of chemicals and apparatus storage. Additionally, both secondary schools were not using practical chemistry laboratory in teaching chemistry and however, 'Adet' secondary school used the laboratory once in a semester to demonstrate a few selected chemistry practical activities. On the other hand, students' laboratory performances were not assessed in both schools and availability of inadequate chemistry laboratory facilities, absence of well-trained laboratory technician, lack of appropriate skills and training of chemistry teachers, and lack of electricity and water facilities to the laboratory rooms were identified challenges in both schools.

Therefore, to attain the aim of chemistry education, all stakeholders should device workable strategies to ensure adequate provision and utilization of laboratory resources for effective chemistry instruction in both schools.

Recommendations

From the findings of this study, the following recommendations are made:

1) Laboratory facilities should be made available by school administrators and the government for meaningful teaching and learning in secondary schools.
2) Chemistry teachers should be involved in capacity building and refreshment retraining, workshops and seminars to help them acquire the skills and keep them up-to-date with the importance for effective teaching and learning of chemistry using laboratory.
3) The government, non-governmental organization, institutions working under education, and the community should also try to equip the school's chemistry laboratories adequately to encourage the teachers to conduct chemistry practical lessons.
4) Chemistry teachers should try to localize the concepts and use the school chemistry laboratory for chemistry instruction until other laboratory facilities are fulfilled.

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