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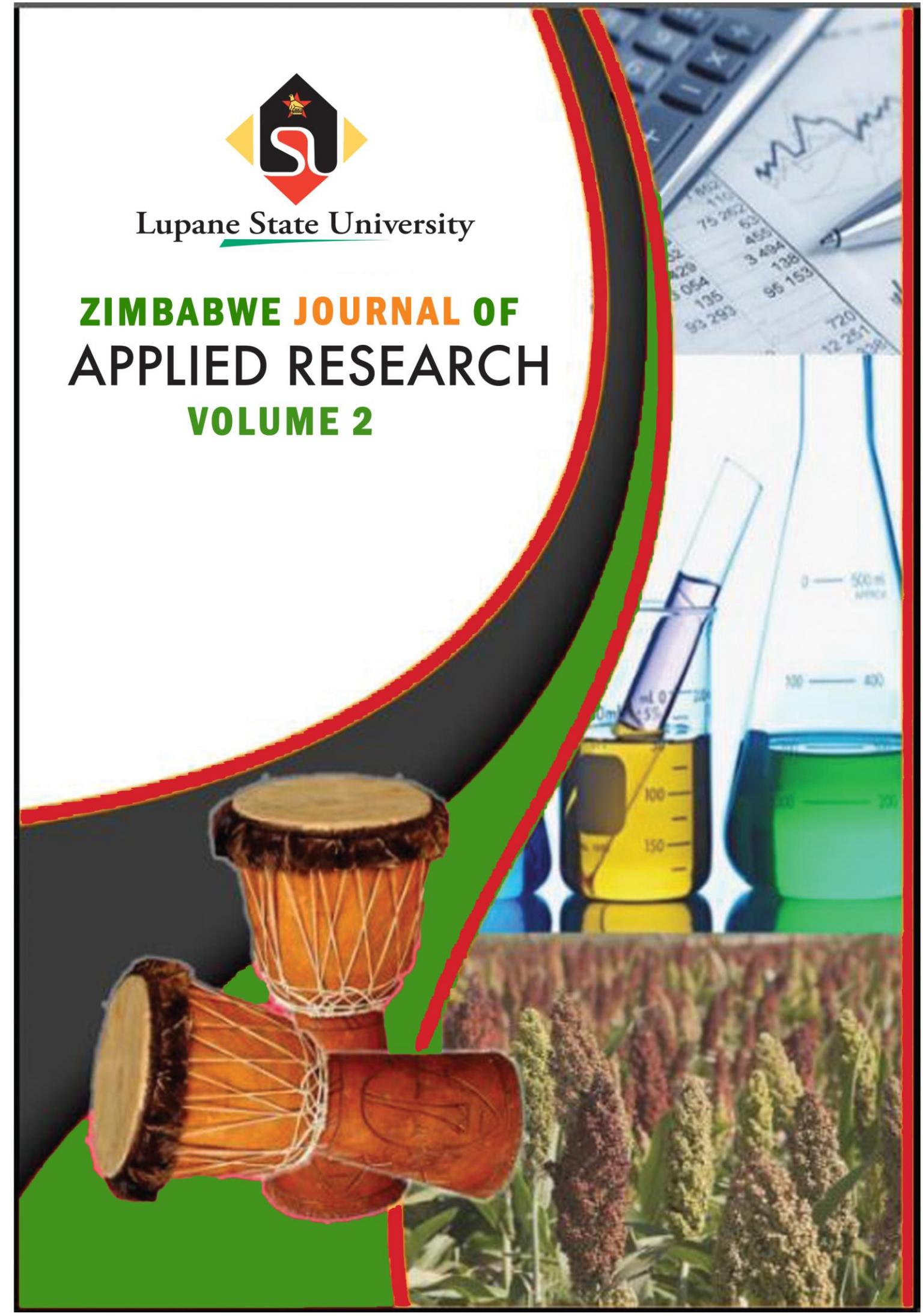

NOTE FROM THE EDITOR

I am pleased that the Zimbabwe Journal of Applied Research continues to grow and is successfully publishing its second issue. Consistent with the multi-disciplinary scope of the journal, articles in the current issue cover child development, education, sustainable development, horticulture, and environmental science. This publication also indicates the geographical expansion of the journal's coverage as shown by the various countries where the contributors in this issue are based. Authors in the current volume are based in Gambia, India, Nigeria, South Africa and Zimbabwe.

The first article by Cletus Moyo and Sikholiwe Dube probes the relevance and applicability of indigenous Ndebele children's games to the 21st century childhood development models and strategies. The article does not only analyze the games in the context of child development fundamentals of today, but it further examines the role of both indigenous and exotic games in addressing challenges faced by today's child. The second article by Muraina Olanrewaju and Hammed Adeoye evaluates the impact of parental attitude on the performance of secondary school students in mathematics. Still in the same area of education, an article by C. Mutseekwa and T.D. Mushoriwa examines the perceptions of science teacher educators and student teachers about professional knowledge standards for science teacher educators. The paper explores the non-alignment of views of teacher educators and student teachers on knowledge and skills required for science teaching.

An article by Herbert K. Chimhowa *et al.* set out to ascertain the appropriateness and effectiveness of rights-based approaches as fundamental schemes for sustainable poverty eradication and development. The study examines the effectiveness of these approaches in the development process and the roles played by development agencies and the government.

The fifth article by Elton Ndlovu *et al*. studied tomato seed germination and seedling growth in various media in a hot bed system. The authors explore various media in a bid to find the ones with optimum production with the economic viability in mind. The last article by G.O. Omoregie and B. Ikhajiagbe scrutinized antioxidant responses of siam weed to heavy metal pollution. The coping mechanisms of the weed to high lead, manganese, zinc, cadmium, and copper concentration are reported. The possibility of the weed decontaminating heavy metal tainted soil was also investigated.

I am greatly indebted to the authors, peer reviewers and the editorial board for their hard work. The Journal is always open to high quality paper submissions. Author guidelines are available on the "ZIM JOURNAL" page on the Lupane State University website www.lsu.ac.zw. As the Journal grows, it is our hope that you will be part of it.

Dr. Getrude Nyakutse

Chief Editor

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Journal Objectives

The Zimbabwe Journal of Applied Research aims to publish peer reviewed articles that employ Scientific Research Methodologies to generate applied knowledge in the fields of Agriculture, Commerce, Social Sciences and Humanities. The journal seeks to give its wide readership evidence based knowledge that bridges the gap between theory and practice. It also offers academia and practitioners across disciplines a platform to assess the merit of their work known to the journal readership.

Editorial Board

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THE RELEVANCE OF INDIGENOUS NDEBELE CHILDREN'S GAMES IN CHILD DEVELOPMENT.

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ABSTRACT

This paper examines the relevance and applicability of indigenous Ndebele children's games to the 21st century child development models and strategies. This is against a backdrop of a generalized tendency to relegate indigenous children's games to the yester year in favor of the so-called 'modern' games that are usually culturally insensitive and indifferent to the unique needs, aspirations, philosophy and worldview of the African child. The paper analyses indigenous Ndebele children's games (which have been passed on through oral traditions) in the context of child development fundamentals of today that seek to build a responsible member of a society. The games include Mbuzi mbuzi mee! Nyama yembongolo and others. The paper notes that indigenous Ndebele children's games are still relevant and applicable to today's world of child development as forms of imparting practical wisdom to the child, enhancers of practical thinking and logical reasoning skills, and as avenues of learning to exist in the world. These games are also relevant in addressing 21st century challenges, scenarios and dilemmas that face today's child, such as HIV and AIDS, human rights issues, sexual orientation issues, gender issues and issues of faith and religion. The paper concludes that indigenous Ndebele children's games are still relevant and applicable to developing a responsible African child who is prepared for both the local and international world. For maximum benefits, the paper recommends that it is not a question of replacing the 'modern' children's games with the indigenous children's games or vice versa, but a question of integrating the two.

***Key Words**: Child development; culture; Ndebele children's games; oral tradition.*

INTRODUCTION

Children and family are highly valued in the Ndebele society (Ndlovu, Ndlovu and Ncube, 1995). As such, this society is rich with mechanisms of grooming children in a way geared to develop them into responsible and wise adults. These mechanisms are partly in the form of children's performances and activities which include games, songs, plays, riddles and storytelling among many. Ndebele traditional children's games are part and parcel of the Ndebele culture. Traditional children's games are culture specific and they reflect the culture of a certain ethnic group. The Ndebele people are a Bantu people mainly found in the Western parts of Zimbabwe (Hadebe, 2002; Khumalo, 2004). Children from the Ndebele society are identified by their games that are mainly articulated in the Ndebele language; however, other languages may be included.

Through these games, children get to know about their world and themselves. Masuku and Ndawi (2001) in Mawere (2012: 60) assert that "children's traditional games are a way of ensuring the continued existence of customs, traditions and culture as a whole". Through games, children learn about their culture, customs, values, belief systems, gender-defined roles and other important issues. Children's games like amadlwane mould children and prepare them for their future roles, teaching them to uphold values such as respect, self-control and other positive values (Mpofu, 2017, interview). This paper advances the argument that indigenous children's games massively contribute to children's development as they socialise them to be creative and innovative thinkers. We advance this argument by analysing children's games purposively sampled from oral knowledge.

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RESEARCH METHODOLOGY

A qualitative approach was used in this research. Purposively sampled games were analysed to examine their relevance to the 21st century child development strategies and models. The games used were purposively sampled from a wide repertoire of children's games. According to Etikan, Musa and Alkassim (2016: 2) purposive sampling "…is the deliberate choice of a participant due to the qualities the participant possesses. It is a nonrandom technique that does not need underlying theories, or a set number of participants" and its advantage is that one can select "the information-rich cases for the most proper utilization of available resources". The games selected were therefore those that we considered information rich in the context of this research. They were selected for their relevance in supporting the current argument. These are games we also played during our childhood years and thus they also offered us an opportunity to reflect on them and examine their relevance to today's children who are living in contexts that are in many ways different from our childhood experiences. The list of games used in this study is not exhaustive.

THEORETICAL FRAMEWORK

Afrocentricity informs this research. Tembo (2012: 59) argues that "Afrocentricity was coined and popularized by Asante". This is an ideology aimed at preserving and reviving African culture. Asante (1987: 6) argues that "Afrocentricity means placing African ideas at the center of any analysis that involves culture and behaviour". This theory instills some sense of positive action on African people. This is buttressed by Tembo (2012: 59) when he states that "Asante emphasizes that Afrocentricity is essentially concerned with centering Africans and not treating them as marginals to Europe". On the same vein, Mkabela (2005: 179) holds that this is a theory of change which is concerned about African identity and it gives subject position rather than object position to African people. The major tenet of the theory that informs the study is Harmosis Mode which is defined by

Gray (2001:98) as: Harmonious synthesis of ancient and traditional African cultural ideas and approaches to life with constructive contemporary cultural possibilities and approaches to life. It is synthesis that benefits and empowers African people and that does not compromise or injure the integrity of African culture.

In addition to the above definition, Matiza (2014: 76) contends that "there should be a combination between modern and traditional culture". Relating this to the study, this implies that traditional children's games should be integrated with modern ones so that children will adapt to a changing world and environment. Children's indigenous and modern games should merge so that they accommodate these children living in a globally changing world. Ndebele indigenous games are becoming more relevant to the 21st century child because they contain functional information that contributes to physical and intellectual development of the Ndebele child. Although Ndebele children live in a global village, they cannot be totally detached from their traditional games which are vital for their culture, customs, values and beliefs.

TRADITIONAL NDEBELE CHILDREN'S GAMES

Many scholars have written about Ndebele children's games and related cultural aspects of the Ndebele people (e.g. Ndlovu et al, 1995; Sibanda, 1998; 2002; Nyathi, 2005; Ndhlukula 1980 and Mpofu 2011). A noticeable characteristic among these scholars is that Ndebele children's games have been seen as part of the Ndebele culture. Nyathi (2005), Sibanda (1998, 2002) and Ndlovu et al (1995) have presented Ndebele children's games as part of the Ndebele culture and there is a clear desire in their writings to preserve these games. Mpofu (2011) points to games as one of the major builders of relationships among children, families and the entire community. Ndlovu et al (1995) do not only document Ndebele children's games but go further to categorise them into those games that are played at home and away from home while herding cattle and other livestock. Ndhlukula (1980) describes Ndebele children's games concentrating mostly on amalibho (riddles) which he presents as important in sharpening the mind of the child. Evidently, these scholars concur that the games play an important role in child development. The current research builds on these earlier works and continues the efforts to document Ndebele children games for future use. The

point of departure for the current study is that it goes further to examine the relevance of the Ndebele indigenous games in child development strategies and models of the 21st century.

Ndebele indigenous children's games cannot be studied in isolation and as exclusively a Ndebele phenomenon. Scholars of African culture and African oral literature such as Finnegan (2012) and Chinyowa (2005) among others have discussed the role of play as part of the African culture. Some Ndebele games are similar to those found in other cultures and ethnic groups. Chinyowa (2005) discusses Shona children's games and explains about matakanana and mahumbwe which are amadlwane in the Ndebele circles. This shows a similarity of Ndebele and Shona children's games. There are similarities between Ndebele and Shona cultures (Mapara and Thebe 2015). This similarity extends to children's games (Mawere 2012). For example, "Posi Posi" or "Sports-sports" is discussed by Mawere as "Sipoti-sipoti" in Shona circles. There are other similarities in other games as well. Differences also exist.

Norgaard and Neitchberg (2004) discuss the importance of traditional children's games and play in Denmark and are of the view that these play a significant part in the educational experiences of a child. The game of "The Bull in the Red Sea" quoted in Norgaard and Neitchberg (2004:1) holds some similarities and differences with the Ndebele children's game "Mbuzi! Mbuzi! Mee!" Traditional children's games are therefore, not a phenomenon exclusive to the Ndebele culture, but a phenomenon that is found in other cultures from Zimbabwe, Africa and beyond and are to be understood within this broad context.

NDEBELE CHILDREN'S GAMES:

IMPLICATIONS FOR CHILD DEVELOPMENT

In this section we present and analyze Ndebele children's games and examine their relevance to child development strategies and models of the 21st century. These games were selected from oral knowledge using purposive sampling. We chose games that we feel represent a wide variety of games played by children; those played at home and those played away from home, those played during the day and those played at night (usually under moonlight), those played by fewer children and those that accommodate large numbers of children, those played by younger children, middle aged children and older children approaching teenage hood. Nyama yembongolo khetha omthandayo (Choose the one you like)

This game is played by having children stand in two lines facing each other, boys on their side and girls on their own. The game is accompanied by a song;

Nyama yembongolo, kheth'omthandayo (My horse choose the one whom you like) Nyama yembongolo kheth' omthandayo (My horse choose the one whom you like) Come on bhizalami, kheth'omthandayo (My horse please choose the one whom you like) Ngifun'olomoy'omuhle, ongancitshaniyo (I want the one who is goodhearted and not selfish)

As this song is sung, boys take turns to go to the girls' line to pick their preferred partners though at times "girls would take turns to choose boys" (Ndlovu et al 1995: 69). This game teaches both boys and girls to make good decisions and choices, particularly concerning life partners. One does not need to look at the outward beauty in the Ndebele context as evidenced by the Ndebele proverb which says "ikhiwane elibomvu libolile" (the red fig fruit is rotten) meaning that the beauty of a woman is not judged by her outward appearance. Thus the one who is searching will say "ngifuna olomoya omuhle… ongancitshaniyo", (I want the one who is good hearted and not selfish). In this game girl children are also encouraged to have good qualities that are seen as desirable; being loving, kindhearted, hospitable and generous. Apart from considering features like outward appearance, boy children are encouraged at this early stage to look for virtues of ubuntu such as kindheartedness, cleanliness and responsibility Interestingly, the Ndebele society, just like many other African societies associate being caring, hospitable, gentle, tenderhearted and loving with femininity. On the other hand, the role of "choosing" and being in charge that is accorded more to boys in this game is associated with masculinity. The reproduction of gendered roles in this game is therefore evident and something that deserves our attention. These games provide an insight into gender issues in the Ndebele culture. This game also promotes unity and

identity in the Ndebele family through collective singing by children.

Posi, Posi, yenda, yenda

In playing this game, children sit down in a circle facing inwards. One of the children goes around the circle singing while others respond:

Leader: Posi! Posi!

(Posi! Posi!)

Response: Yenda! Yenda!

(Go! Go!)

Leader: Ngiding' umntwana

(I am looking for a child)

Response: Yenda, Yenda!

(Go! Go!)

Leader: Umagezis' imnganu

(The one who washes plates)

Response: Yenda! Yenda!

(Go! Go!)

Leader: Eyihlambulule

(Who washes plates very well)

Response: Yenda! Yenda!

(Go, go)

Leader: Wena angikufuni

(I do not want you)

Wena uyidoti, idoti kaMazayi

(or Wena unuka idoti, idoti kaMazayi)

(You are dirty like the Mazayi sewage stream,

or you smell of sewage waste from Mazayi)

Mina ngifuna lo onuka isikhiwa!

(I want this one who smells good)

"Yenda! Yenda!" remains the refrain throughout the song. In English this phrase means "Go! go!" so the children are encouraging the leader of the song to "go, go" implying that he or she is to keep on searching. At his or her discretion, the one moving around the circle settles on one person and declares "wena angikufuni, unuka idoti, idoti kaMazayi" (I do not want you, for you smell bad, like the Mazayi stream) and then moves to his or her choice and declares "mina ngifuna lo onuka isikhiwa!" (I want this one who smells good). The one chosen stands up and joins the one going around the circle until there is only one child left sitting. Being the one who remains unchosen is undesirable and so each child anticipates that he or she will be selected. Being known for cleanliness increases chances of being chosen whilst being known for untidiness reduces chances for one to be selected.

Seemingly, this game or its song has been adopted into the Ndebele culture because we are living in a global village. It reflects cultural hybridity associated with urbanization. The lyrics "Idoti kaMazayi", denotes an urban phenomenon. 'Mazayi' is a dirty sewage stream which passes through the oldest locations like Makokoba and Thorngrove in Bulawayo (Mpofu, 2017, interview). All the sewages from the industries in the city would flow through this stream which is well known for its bad odor in the locations. Hence, the child who remains unchosen is associated with the bad smell in this stream. The main gist of this game lies on cleanliness. Cleanliness remains a major concern among children and their environments and this game still possess the potential to cultivate this among children. Possibly this game is influenced by Shona culture and language. "Yenda, yenda" in this case is likely Shona lexical item. Mawere (2012) makes reference to this game when he writes about Shona children's games. The cultural hybridity in this game shows how, in global contexts, cultures are decentered constructed and shifting in nature. Culture is now a process and not a pinned down system (Clammer, 2005).

"Posi Posi" is sung as "Sports, Sports" in other circles, arguably a result of colonisation by Britain as also highlighted that the preferred child is the one "onuka isikhiwa" loosely translated as "one with a white men's smell". "Isikhiwa" among the Ndebele is a term synonymous with progress, civilization, advancement

and prosperity. The association of civilisation and progress with "isikhiwa" reflects eurocentrism that celebrates "whiteness" and looks down on people of colour. Such mentality is a result of colonisation. Whilst this game is valued as part of Ndebele cultural heritage, negative contours of our history contained in this game cannot be ignored.

Bantwana bantwana wozani ekhaya (Children come home)

This game reflects the role of parents as protectors for children in times of danger. In this game a girl child who represents a mother and a boy child who represents a father stand on either side of the home (Ndlovu et al (1995). As the game progresses either the father or mother calls his/her children to come home, but there are lions on the way (played by other children lying in ambush). The children on the other side respond by telling him or her that they are afraid of lions or hyenas. He or she assures the children that lions are no longer there. They run home to the other side. On their way surprisingly, the lions surface as children are in the process of running home, but they run fast dogging them in order to escape. The game goes as follows;

Leader (mother/father): Bantwana bantwana wozan' ekhaya!

(Children, please come home!) Response (children)

: Siyesaba! (We are afraid!)

Leader: Liyesabani?

: (What are you afraid of?)

: Response: Impisi! (Or Izilwane!)

: (Hyenas!) (Or Lions!)

Leader: Impisi kudala zafa zaphela zathi du!

(Hyenas died long ago, all of them!)

Children then run across to the other side. Hyenas or lions come out of hiding to catch the children. Those caught become hyenas or lions. The game continues until a few winners remain. (Ndlovu et al, 1995: 70).

Those who run slowly are caught by lions and also become lions. Dodging lions teaches children to come up with quick solutions whenever they face problems in life. Being strategic and alert are key elements cultivated. The game is also a good source of physical exercise.

Mbuzi mbuzi mee! (Goat, goat mee!)

This game is played by a group of children who form a circle through standing and holding hands. One child who plays the "goat" would be inside the circle and would try to get out of the circle by bumping himself on the hands of the other children while saying "mbuzi mbuzi mee!" (Goat, goat, mee!). The children in the circle stop him while saying "iyangaphi emasimini abantu?" (No going to people's fields!) or "wadla amabele kababa!" (You grazed on my father's crops!). This goes on until the child in the circle breaks through the circle. Others chase him/her until they catch him/her. The one who catches him/her gets the privilege to play the "goat" or children just rotate playing the "goat".

This game encourages children to be each other's keeper, peer educators and counselors. Children learn to educate each other in a way that will prevent undesirable behaviour among their peers. In today's context it encourages children to discourage peers from drug abuse, bullying and other such undesirable behaviour. This game could have also functioned as a way of encouraging children (especially the boy child) to grow up with a sense of responsibility to construct strong boundaries for kraals and for fields in order to prevent domestic animals from grazing on cultivated crops. The Ndebele people are agriculturalists and thus crops and livestock should be cared for amicably to avoid loss of crops and misunderstandings that may occur when one's livestock graze on a neighbor's crops.

Madlwane (role play game)

In the Ndebele society each and every child passes through this stage of playing amadlwane. Some scholars have used the term "amandlwana" (Nyathi 2005: 14) and some use the term "amandlwane" (Sibanda 1998:116, Sibanda 2002: 109). This game is played by two different groups of children in the

Ndebele society (Mpofu, interview). It is played by little children (3 -8 years) who dramatise everything they see their parents doing. During the game boys and girls perform various duties and roles just like the husband, wife and children in a family set up. Children enact all that they see happening in the families they have been exposed to. For instance, one can find them acting out a family setup with domestic violence or polygamous family. In most cases boy children play the role of a father while one of the girls assumes the role of a mother and with the rest of children playing the role of children in the family. In playing the roles of father and mother children are not expected to engage in sexual activities. There are scenarios where girl children would play this game on their own when the boys are not there.

Chinyowa (1999:77) notes that these roles prepare children for the future actual roles of being parents. This was also echoed by Mpofu (2017) in an interview where he emphasised that amadlwane played an important role in preparing children for adulthood and inculcating in them positive values such as respect, self-control, collaboration and togetherness. This game develops the child socially and mentally. It also cultivates self-awareness in the child.

Ndebele traditional games such as amadlwane provide Ndebele children with a platform to learn about their own culture and values. Nyathi (2005: 14) observes that:

Among the Ndebele, moulding of figurines using clay was undertaken by children. It was part of amandlwana (child play. The games played by Ndebele children miniaturized adult activities. Boys's amandlwana embraced molding, with clay of figurines…As a children's play activity, making figurines was carried out away from adults. It was undertaken either near or beyond the fence of the homestead. The boys, as future herd boys, molded mostly cattle.

Clearly, children's games used to play and continue to play an important role child socialisation, teaching children ways of existing in the world. They are prepared for future responsibilities in a way that makes then responsible citizens in the society.

According to Sibanda (2002: 109), in the second scenario the game is played by both grown up boys and girls (aged about fifteen years). This is a real game where children act real events that foreshadow their future life. The game is played during the time of harvest for some days. Sibanda goes on to explain that this is a game which was played by both boy and girl children during the harvest period. They go and build their "home in the bush" (p. 109). They leave home with axes, pestle and mortar, pots and plates. On that very day girls ask for dried maize and take it to the bush. Boys cut down branch trees and build boots. Those boots become their home during the time of play.

As the game advances boys go out in the bush to hunt wild birds so that girls would prepare sadza and bird meat. After eating they leave their plates in the bush so that they will use them for tomorrow. Sibanda (2002) postulates that the purpose of this game is aimed at giving children time to learn about their future responsibilities as men and women, primarily fending for the family. Importantly, children learn their gender specific roles in line with societal expectations. It also gives children time to see interact with each other

Amadlwane for the younger children (3 to 8 years) are still played today, but the other category for those around 12 to 15 years is a phenomenon that has faded away. Amadlwane are similar to what is termed mawumbwe and matakanana in Shona (Chinyowa 2005:76). Slight differences may, however, be noted in how the games are played in Ndebele and Shona circles.

Amadlwane present learning and growing platforms to the 21st century child. Technological advancements such as conventional media (for example, television) and social media (face book, twitter, Instagram, WhatsApp and among many others) that we enjoy today are undeniably good and beneficial (at times highly necessary), but they sometimes isolate a child and deny him or her the opportunity to grow within a community of other children. Mawere (2012: xii) notes that traditional children's games in Zimbabwe have been sidelined or marginalized in favor of modern activities like watching television and track and field games such as golf, cricket, rugby, wrestling, boxing, netball, tennis, horse racing and soccer. Children's

games therefore, need to be accorded a space in child development processes. The role of child plays close gaps in the growth processes of children.

Amalibho (Riddles)

Riddles are indirect phrases or statements referring to famous substances and they are characterised by question and answer form. African children participate in riddling each other. Finnegan (2012:413) holds that "… riddles in Africa have regularly been considered to be a type of an art form, albeit often of minor and children's interest…" Makaudze (2014: 132) asserts that "the game of riddling is normally played by children of both sexes, usually at night as they entertain themselves waiting for supper". Riddles are part and parcel of the Ndebele culture. Riddles are usually for entertainment but are also vital in the social and cultural education of children.

Finnegan (2012:427) argues that "besides entertainment, riddles are sometimes claimed to play an indirect educational role by training children in quick thinking, intellectual skills and in classification…" Similarly, Gelfand (1976) contends that riddles are useful tools in children's cognitive development; critical thinking and they teach good behaviour. The thrust of this game is to examine the depth of the child's brain and also to see how clever he or she is. Riddles gauge the child's brain and development, his or her listening skills, communication and thinking patterns.

In this game children are taught to be fast thinkers as one in the game would be riddled and has to respond within a short period of time. Riddles seek to perceive how intelligent and sharp the child's memory is. Mawere (2012) in Mutema (2013: 60) holds that "games were meant to sharpen children's intellect as well as, prepare them to confront and solve real life problems". Thus the role being played by Ndebele riddles in child development should not be underestimated. Riddles are still valid today and their use for child development remains viable. Below are examples of Ndebele riddles and their answers.

1. Ngikulibha ngomfana wam' odl' ekhafula. (I riddle you with my boy who eats while spitting the food).

Answer: Lihloka kuganyulwa isihlahla. (An axe in the process of cutting down a tree).

2. Ngikulibha ngobhoda ngapha sizahlangana ngapha. (Go this way we will meet this side).

Answer: Libhanti (belt).

TRADITIONAL NDEBELE CHILDREN'S GAMES AND CHILD DEVELOPMENT PSYCHOLOGY

Children's games have been seen as vital to the area of child development psychology and educational psychology. Chinyowa (2005:77) observes the following concerning mahumbwe (an equivalent of amadlwane in Ndebele circles):

The game can be regarded as a crucial phase in the process of growing up. In fact, there appears to be a link between this 'playing house' game with John Adam's paidocentric education (in Courtney, 1974), described as education from the child's point of view or with John Dewey's 'learning by doing', since the children will be learning 'future' adult roles.

John Dewey (1916) advocates for hands on approach to education which consists of learning by doing. Participatory learning is also advocated for by Freire (1971) who has criticized the traditional lecture method in education, arguing that the best scenario is to have students being active participants in their process of education and not mere observers. Ndebele traditional children's games provide a platform for children to be active participants in their educational processes.

Norgaard and Eitchberg (2004) in their analysis of traditional games in Denmark came to a conclusion that these games are important in the educational experiences of children. Their observation is similar to ours regarding Ndebele traditional children's games. The importance of the Ndebele traditional children's games in the educational experiences of children runs through the works of the Ndebele writers that have written about these games (Sibanda 1998, 2002, Nyathi 2005, Ndhlukula 1980, and Ndlovu et al 1995). Mawere (2012) writing on Shona traditional children's games has argued that they are important in the educational experiences of children. This is also echoed by Ntsihlele (2009) writing on Sotho children games. She argues that play and games have an important role in child development education. It is therefore evident that traditional children's games from the Ndebele

culture in particular and from the Zimbabwean culture and beyond in general do play an important role in child development psychology and in educational psychology.

Ndebele children's games mirror the Ndebele culture and signify how children in the society connect to the adult world. Snel (2009: 3) postulates that "since these games are still being played today, the past and future are bridged… children are still connected to their past to some extent and these traditions are still being kept alive by means of play". Ndebele performances are not old fashioned, instead they are still pertinent to children in the contemporary society and thus they are even incorporated into the Zimbabwean Early Childhood Development (ECD) and Pre- School education systems.

Finnegan (2012: 300-1) asserts that "schools are becoming increasingly important in the lives of more and more children in Africa, it is likely that similar singing games-from whatever source-are now wide spread (and thus accessible to study) among school groups…". However, the current Zimbabwean ECD syllabus includes a lot of modern games and plays compared to the traditional ones. This is evident in ECD syllabus (2012:17) where only umacatshelana (hide and seek) and ingqobe (challenge game) are mentioned as activities those children engage on.

Despite the traditional games being few, their inclusion in the curriculum on its own is a big development to the Ndebele community and nation at large. These indigenous games should be given more time in the ECD education system because they are a carrier of culture, norms and values. Their inclusion in the ECD syllabus becomes a way of preserving and reviving these games for future use. This is in line with the Harmosis Mode which informs this study as it puts much emphasis on the integration of both the past and present as a way of empowering African people.

CONCLUSION

Traditional Ndebele children's games are essential in the social, cultural, physical as well as psychological development of children. They bring children together, fostering unity of the community and instilling essential values of responsibility, cooperation, participation and making informed choices and decisions. These games are still relevant and applicable in the 21st century. However, modern children's games equally play an important role in the development of children. A balanced approach in child development is therefore desirable. Such an approach should revive, promote, encourage and use Ndebele indigenous children's games that are seen to be relevant today side by side with modern games that hold an equally good value. For maximum benefits, we recommend that it is not a question of replacing the modern children's games with indigenous children's games or vice versa, but a question of continuity, integrating the two and adopting these games as seen fit by the Ndebele contemporary society

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PARENTAL ATTITUDE TOWARDS DISCIPLINE AND DEVIANCE: IMPLICATIONS ON MATHEMATICS ACHIEVEMENT OF SENIOR SECONDARY SCHOOL STUDENTS

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ABSTRACT

The purpose of this study was to investigate parental attitude towards discipline and deviance: implications on Mathematics achievement of senior secondary school students. Descriptive research design of ex-post-facto type was used in the study. Nine hundred and ninety-two respondents were selected randomly from 10 Local Government Areas in Ibadan, Oyo State. The respondents were measured with validated instruments and the data were analyzed using Pearson Product Moment Correlation (PPMC) and Multiple Regression statistical analysis. Three research questions were raised and answered in the study. The result showed that academic achievement of senior secondary school students in Mathematics is significantly correlated with parental attitude towards discipline and parental attitude toward deviance, the independent variables when pulled together have significant effect on academic achievement in Mathematics and the independent variables made a significant contribution to the prediction of academic achievement of senior secondary school students in Mathematics. In term of magnitude of contribution parental attitude towards discipline made the most significant contribution to the prediction of academic achievement in Mathematics followed by parental attitude toward deviance. In view of these findings, the study recommended that educational psychologists should intensify their effort to organize conferences on the implications of these variables as they affect the students' Mathematics achievement in the school.

Keywords*: Parental attitude, Discipline, Deviance, Academic achievement, Senior secondary school students, Mathematic.*

INTRODUCTION

Mathematics is one of the compulsory subjects that students must study in the school system regardless of whether the students are majoring in physical science, commercial, arts or social science. In the secondary school curriculum, according to the National Policy on Education (2013), Mathematics is one of the core subjects that for the students to further their studies in institutions of higher learning especially at university, students are expected to have credit in it. This makes Mathematics one of the essential subjects for students' advancement. Mathematics is one of the subjects that is taken very seriously in the school system, irrespective of the level of education. In terms of curriculum relevance, Mathematics is compulsory at the secondary school level and a prerequisite for moving from the Junior Secondary School (JSS) to the Senior Secondary School (SSS); just as at the tertiary level of education, a sound background in Mathematics is a necessary condition for the study of all science, technology and social science based courses, as required by the Unified Tertiary and Matriculation Examination (UTME) in Nigeria.

A growing body of literature supports the importance of school personnel understanding and appreciating the unique strengths and contribution of parents to the success and failure of students. African parents have the difficult role of orienting their children toward an environment that is restrictive and hostile towards students (Muraina and Muraina, 2014). Parental attitude towards discipline and deviance in education is key to the

level of teachers' satisfaction (Lavay, French, and Henderson, 2007). The truth is parents in Nigeria do not exert more influence on their children's intellectual development than is commonly realized in developed countries (Owoyele and Muraina, 2015; Muraina &

Issac, 2017). In fact, more than three decades of research shows that parents have greater influence than any other factor. It has been realized that for parents the right to learn is curtailed by the obligation to attend school. Muraina (2018) found that many children in Nigerian schools feel that they are forced to go to school and that parents seem to be a distance away from what is happening in the school.

LITERATURE REVIEW

Addressing problems of inappropriate behaviour and discipline are just a few of the tough jobs parents are expected to do. Unmotivated students, increased violence, lack of resources and large class sizes are a few of the problems facing the nation's schools (Muraina and Muraina, 2014). It is not surprising then that society as a whole perceives lack of discipline as a major concern in today's public schools. In addition, the way teachers address the more global problem of empowering students to successfully manage their own behaviours is the most difficult task. Increasing appropriate behaviour and decreasing inappropriate behaviour is essential in creating a safe, positive, and nurturing learning environment (Lavay, French, & Henderson, 2007). There are many different approaches and strategies teachers can use to provide opportunities for students to learn how to decrease the occurrence of discipline problems in their classes. The following are back to basics strategies that all teachers should re-visit either as a reflection on current practice or as a primer when starting a new task (Muraina and Isaac, 2017). In spite of researches and various scholarly works on the predisposition on implementation of positive discipline by secondary school teachers, there is little or none that combined parental attitude towards discipline and deviance together as predictors of academic achievement of senior secondary school students.

Parental attitude is defined as parents' commitment and disposition to the discipline and deviance of their children, and the role they play in school management. Across international studies reviewed, parental attitude towards discipline was measured as participation in parent-teacher conferences and/or interactions, participation in school activities or functions, engagement in activities at home, including but not limited to homework, engagement in learners' extra-curricular activities, assisting in the selection of learners' courses, keeping abreast of learners' academic progress and autonomy of support in the home environment (Gonzales, 2005; Muraina and Issac, 2017). Parents are at the forefront in ensuring that their children receive an education. However, sending them to a particular school without ensuring it has a proper environment in which they can learn can undermine their good intentions (Muraina, 2018).

Hoover-Dimpsy & Sandler (1995) stated that parental attitude towards discipline influences children's development and educational outcomes through such mechanisms as modelling, reinforcement and instruction. Parents who like reading, for instance, are likely to influence their children also to like reading. Everyday experiences with homework, as mediated by parents, provide opportunity and instructions associated with doing homework (Xu & Carno, 1998). This can also reinforce the child's good learning behaviour by offering incentives after academic attempts and success. Hoover-Dimpsy and Sandler conclude that major educational outcomes of parental attitude towards discipline and deviance are in their children's development of skills and knowledge, as well as their personal sense of efficacy to succeed in school (Muraina and Issac, 2017).

Durant (2011), posited that parental attitude towards discipline is an important component of their early school success, echoing findings by Lee & Bowen (2006) from a study of the level and impact of five types of parental attitude towards discipline and deviance in elementary school. Most researchers maintain that parents have an important influence on children's personality and social development (Muraina and Muraina, 2014; Muraina, 2018). Topping (1986) concurred that parents are role models to their children who transmit, through examples, values, norms, and attitude. The basis for co-operative nursery schools is the acceptance of parents as teaching assistants (Yussen and Santrock, 1982). In Africa, Mouly (2012) wrote that if a pupil does not do or

complete assignments and the teacher's attempts to change this behaviour are unsuccessful, he/she should bring the problem to the attention of the principal or the parents.

The Nigerian Council for Educators (Act 31 of 2000) recognises parents as partners in education and stipulates that educators must do what is practically possible to keep parents adequately and timely informed about the wellbeing and progress of their children. Durant's (2011) analysis of Latino families showed that parental attitude towards discipline was a significant predictor of children's literacy skills above controls and that stronger communication with parents may be instrumental in increasing both home and school task performance, creating a possible avenue through which the parents might develop a collective voice within the school sector. Hsu, Zhang, Kwok, Li, and Ju (2011) used a sample drawn from Taiwan to evaluate the role of parental attitude towards discipline and found that mothers were more involved than fathers in education and that their involvement had more predictive power of adolescent academic achievement.

Parental attitude toward deviance is the reaction of parents in correcting any manifested bad conduct or behaviour of students in their custody. Hsu, Zhang, Kwok, Li, and Ju (2011) observed that parental attitude toward deviance had positive impact on student achievement, but participation in school activities did not significantly affect it. Nye, Turner and Schwartz (2006) support the use of parental attitude toward deviance to improve children's academic performance, and argue that its effect outside school has practical implications for parents, educators, administrators, and policymakers. In addition, when used as a supplementary intervention, it increases children's academic achievement, with programmes also a way of encouraging parental attitude toward deviance.

Studies (e.g Hill and Craft, 2003; Muraina, 2018) of learners from primary to secondary schools show a beneficial relationship between parental attitude toward

deviance and learner variables such as academic achievement, sense of well-being, attendance, learner attitudes, homework and educational aspirations.

However, according to Gaynor (1998), many countries are still grappling to cope with the new role of parents as active stakeholders in education. Presently, in Nigerian schools, most parents do not participate meaningfully in their children's education and discipline, this is evident in the poor attendance of parents at Parents' meetings, low attendance at Parent-Teacher Meetings, recalcitrance in paying school fees, inability to maintain proper control of learning support and lack of interest in learners' school work and homework (Mestry, 2004; Muraina and Issac, 2017).

Parental attitude towards discipline and deviance is of increasing interest to researchers of education systems (Muraina, 2018). The discomfort is related to difficulties in getting parents to collaborate, and also to teachers' coping with parents' feelings of disrespect and mistrust toward them, and to parents' over protectiveness of their children or questioning teachers' authority (Fisher, 2009). Previous studies (e.g Owoyele and Muraina, 2015; Muraina and Issac, 2017; Thomas, Curtis, and Shippen, 2011) have compared attitudes and functioning of teachers and counsellors, yet a search of the literature did not yield the influence of parental attitude towards discipline and deviance on academic achievement of senior secondary school students in Mathematics in school.

STATEMENT OF THE PROBLEM

The habit of studying is formed in childhood and a child's taste in reading is formed in the right direction or wrong one while he/she is under the influence of parents and they are directly responsible for shaping and cultivating that taste. The failure by parents to have influence over their children is a source of concern as it is reflected in the uncompromising stance taken by teachers to find ways of forcing parents to come to check on their children's welfare or academic performance during school open days. This has resulted in teachers' level of satisfaction in their profession being negatively affected. Failure by parents to talk to children about their academic performance is a sign that parents influence in schools

is wanting. The problem this study is trying to contribute a solution to is low levels of teacher's job satisfaction in secondary schools and the reluctance of parents to be involved or support the students learning process. In view of this, the present study concentrates on the parents' attitude towards discipline and deviance and its implications on Mathematics achievement of senior secondary school students.

OBJECTIVES OF THE STUDY

The objectives of this study were to:

1. determine the relationship between parental attitude towards discipline and deviance and academic achievement of senior secondary school students in Mathematics

2. examine the joint contributions of parental attitude towards discipline and deviance on academic achievement of senior secondary school students in Mathematics

3. investigate the relative contribution of parental attitude towards discipline and deviance on academic achievement of senior secondary school students in Mathematics

RESEARCH QUESTIONS

1. What is the relationship between parental attitude towards discipline and deviance and the academic achievement of senior secondary school students in Mathematics?

2. What is the joint contribution of parental attitude towards discipline and deviance on academic achievement of senior secondary school students in Mathematics?

3. What is the relative contribution of parental attitude towards discipline and deviance on academic achievement of senior secondary school students in Mathematics?

METHODOLOGY

The study adopted the descriptive survey design of *ex-post facto type*. This involves the use of questionnaires to source information on parental attitude towards discipline and deviance on academic achievement of senior secondary school students in Mathematics. In this study, the independent variables are parental attitude towards discipline and deviance while the dependent variable is academic achievement in Mathematics. The population for this study is all 74,000 senior secondary school students in Oyo State, Nigeria. The population covers all the Local Government and secondary schools in Oyo State, Nigeria. Simple random sampling technique was used to select the participant for this study. Simple random sampling technique was used to select 10 Local Government Areas in Oyo State. In each randomly selected Local Government Areas, 10 secondary schools were selected through balloting. Also, 10 senior secondary school students (participants) were randomly selected in each selected schools. On the whole, the total number of participants in this study were one thousand (1000) and these were senior secondary school students with an average age of 22.7 years. Out of 1000 questionnaires distributed only 992 were properly filled and used for data analysis.

Parental Attitude towards discipline and Deviance Scale.

The Attitude towards Behaviour Management Scale developed by Nancy and Daniel (2009) was used to measure the parental attitude towards discipline and deviance. The instrument is made up of 24 items original. But 20 items were adapted. The scale had two sections which are attitude toward discipline and attitude towards deviance. The first ten items measure parental attitude towards discipline while the remaining ten items measures parental attitude toward deviance. The response format was in 4-point format with response options ranging from (4) Always (3) Almost Always (2) Usually Sometimes (1) Never. This questionnaire was administered to the parents. The scale had internal consistency of .76. The

instruments were pre-tested on 30 respondents which were not included in the scope of the study to ascertain the reliability of the instrument. After the pre-test, the instrument was scrutinized and necessary modifications were made before final administration. The reliability co-efficient of the

instrument was 0.89.

Mathematics Achievement Test

This was made up of 40 multiple choice items with four options (A-D). All the questions were answered by theparticipants within an hour. The reliability coefficient of the instrument was determined using Kuder – Richardson formula 20 (KR20). Kuder – Richardson formula 20 (KR20) was used to determine the internal consistency and overall coefficient of the instrument. Item analysis was also carried out to determine the difficulty index and discriminatory power of the test. This was done between the higher achievers and lower achievers in Mathematics. The difficulty and discriminating indices of each of the test items was computed for further validation of the instrument. The difficulty level of .48 to .55 and the discrimination index of .71 to .79 were obtained. However, writing of test items was followed by face and content validation. The face and content validation reduced the items from 70 to 55 after subjecting the test to thorough screening among 3 Mathematics teachers in secondary schools; while item analysis further reduced the test items from 45 to 41. The selected items were administered on thirty students. Kuder-Richardson formula (KR) was applied to the scores in order to measure the internal consistency. The internal consistency coefficient of .79 was obtained and this showed that the test was very reliable and could be used for the study.

The instruments were administered to the participants on the day approved by the school authorities for the exercise. Five research assistants were employed in the administration and collection of the instruments. In each of selected Local Government Areas and Schools, the administration and collection of instrument was done on the same day of administration. On the whole data collection lasted for approximately 8 weeks. Out of one thousand questionnaires administered only nine hundred and ninety-two were properly filled and used for data analysis. Pearson Product Moment Correlation (PPMC) and Multiple Regression statistical analyses were used to analyze the data. PPMC was used to establish the relationship among the variables as raised in research question one while the multiple regression was used to establish the joint and relative contributions of the independent variables on the dependent variable as raised in research question two.

RESULTS

Research Question One: What is the relationship between parental attitude towards discipline and deviance and academic achievement of senior secondary school students in Mathematics?

Table 1: Inter-correlations among the variables

Variables	N	Mean	SD	1	2	3
Mathematics Achievement	992	39.69	15.34	1.00		
Attitude to Discipline	992	24.25	9.38	.671	1.00	
Attitude to Deviance	992	25.66	11.99	.859	.585	1.00

Correlation is significant at the 0.05 level (2-tailed)

Table 1 contains inter-correlations among the study variables. As shown in the Table 1, academic achievement of senior secondary school students in Mathematics is significantly correlated with parental attitude towards discipline ($r = .671$; $p<.05$) and parental attitude toward deviance ($r = .859$; $p<.05$). There were also significant correlations among the independent variables.

Research Question Two: What is the joint contribution of parental attitude towards discipline and deviance on academic achievement of senior secondary school students in Mathematics?

Table 2: Multiple Regression Analysis on Mathematics Achievement Data

R = .812
Multiple R(adjusted)=.731
Multiple R^2(adjusted)=.729
Standard error of estimate= 5.338

	Analysis of variance			
	Sum of Square	DF	Mean square	F
Regression	37377.62	2	18688.81	171.79
Residual	107591.63	989	108.79	
Total	144969.25	991		

Table 2 shows that the independent variables (parental attitude towards discipline and deviance) when pulled together have significant effect on academic achievement of senior secondary school students in Mathematics. The value of R (adjusted) =.731 and R^2 (adjusted) =.729. The analysis of variance performed on the multiple regressions yielded an F-ratio value of 171.79 with 72.9% of independent variables accounted for academic achievement of senior secondary school students in Mathematics and was found to be significant at 0.05 level.

Research Question Three: What is the relative contribution of parental attitude towards discipline and deviance on academic achievement of senior secondary school students in Mathematics?

Table 3: Relative Contribution of Independent Variables to the Prediction

	Unstandardized coefficients	Standardized coefficients		t	p
Model	B	Standard error	Beta		
Constant	22.885	1.786		12.814	.000
Attitude to Discipline	1.179	.356	.720	21.067	p<0.05
Attitude to Deviance	1.476	.352	.310	14.062	P<0.05

Table 3 shows that the independent variables made a significant contribution to the prediction of academic achievement of senior secondary school students in Mathematics. In term of magnitude of contribution parental attitude towards discipline made the most significant contribution

(Beta= .720; t= 21.067; p<0.05) to the prediction of academic achievement of senior secondary school students in Mathematics follow by parental attitude toward deviance (Beta= .310; t= 14.062; p<0.05).

DISCUSSION OF FINDINGS

The result of the first research question indicates that academic achievement of senior secondary school students in Mathematics is significantly correlated with parental attitude towards discipline and parental attitude toward deviance. This is in agreement with the finding of Gonzales (2005) who found that parental attitude towards discipline was measured as participation in parent-teacher conferences and/or interactions, participation in school activities or functions, engagement in activities at home, including but not limited to homework, engagement in learners' extra-curricular activities, assisting in the selection of learners' courses, keeping abreast of learners' academic progress, reaction to academic grades, imparting parental values, and the level of parental control and autonomy of support in the home environment. Hoover-Dimpsy and Sandler (1995) of the schools. This will help in enhancing the motivation of the students and invariably improve students' Mathematics achievement in the school.

Parents and guardians need to change their attitude towards discipline and deviance. This is because attitude towards discipline and deviance significantly influence Mathematics achievement of the students.

CONCLUSION

Based on the findings of this study, persistent poor academic achievement of Nigerian secondary school students in mathematics need not to continue indefinitely. There is hope that with the improvement of parental attitude towards discipline and deviance, the situation can be changed for the better. The study discovered that parental attitude towards discipline and deviance has significant effect on Mathematics achievement of secondary school students in the school. As such, it is very crucial to improve on parental attitude towards discipline and deviance so as to eradicate the persistent occurrence of students' poor academic achievement in this great subject.

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PROFESSIONAL KNOWLEDGE STANDARDS FOR SCIENCE TEACHER EDUCATORS IN ZIMBABWE: PERSPECTIVES OF SECONDARY SCHOOL SCIENCE TEACHER EDUCATORS AND SCIENCE STUDENT TEACHERS.

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This study examined professional knowledge standards for Science teacher educators in Zimbabwe as perceived by both Science teacher educators and Science student teachers. An exploratory mixed methods research design, within the post-positivist paradigm, was used to guide the collection and analysis of data. Data were sourced from 18 Science teacher educators and 108 final year Science student teachers pooled from two secondary school Teachers' Colleges through a semi-structured questionnaire, follow-up interviews, focus group discussions and documents. Major observations from the study were that science teacher educators were highly knowledgeable in subject content but had lesser skills and knowledge on transforming the same content into learnable experiences. Science student teachers from the two colleges concurred that laboratory-based practice, modelling of exemplar teaching, research and knowledge on the nature of science constituted an important part of a science teacher educator's repertoire, and therefore, the three aspects were crucial to science teacher education. One of the major recommendations of the study was that science teacher educators need to refresh their knowledge and skills for Science teaching through engagement in active research in order to utilize diverse knowledge to support science teacher education and pedagogy.

Keywords: *perspectives, professional knowledge, Science teacher educators, Science student teachers, standards.*

INTRODUCTION

This study examined professional knowledge standards for Science teacher educators in Zimbabwe as perceived by both Science teacher educators and Science student teachers. It is important to examine professional standards for Science teacher educators because the teacher educators' professional knowledge and standards are critical to the development of effective Science student teachers. Given this dimension, the study takes lofty significance in that the teacher educators' possession of sound professional knowledge and by extrapolation, skills, will help to produce Science teachers with sound pedagogic practices and know-how. Kim, Ham and Paine (2011) contend that past research has not dwelt much on what knowledge science teacher educators should have. Given this contention, there is enough justification for the present study.

BACKGROUND AND LITERATURE REVIEW

While literature (e.g. Stotsky, 2006; Vingsle, 2014) is replete with professional competencies of a teacher, there seems to be a paucity of literature on professional standards for Science teacher educators. Adequate research on teacher educators' knowledge is missing (Goodwin, Smith, Sauto-Manning, Cherevu, Reed & Taveras, 2014) yet teacher educators, most of them coming from schools, either primary or secondary, grapple with a number of challenges regarding knowledge and skills required in their job. For Berry and Van Driel (2012), research on what teacher educators know, how they act and why, is rare. Loughran (2014) also argues that there is a research gap in this area which has motivated recent researchers (e.g. Goodwin, Smith, Sauto-Manning, Cherevu, Tan, Reed and Taveras, 2014) to focus on this area.

From the above argument, there seems to be a growing realization of the need for researchers to focus more attention on the knowledge and skills that science teacher educators must possess. Teacher educators come from a variety of backgrounds and as such, they enter into the field with differences in beliefs, perspectives, experience, knowledge and skills. As already argued, most of the initial knowledge they bring to teacher education is from schools. This is despite the fact that teacher education is a completely different field from secondary or primary school teaching. Many studies (e.g. Berry & Van Driel, 2012; Loughran, 2014) have demonstrated that basic and higher education require different skills. There are differences in the nature of routines, working conditions, environments, learner levels and curriculum, which present the teacher educator with a need for a novel set of knowledge and skills without necessarily discarding the previous ones (Loughran, 2014). The teacher educator needs skills that are above those of classroom teaching because teacher education has increased challenges, demands, expectations and requirements.

Adequate research and discourse on teacher educators' knowledge is missing (Goodwin, Smith, Sauto-Manning, Cherevu, Tan, Reed, & Taveras, 2014). The bulk of the

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research in the area focuses on primary and secondary teacher knowledge and skills for science teaching. Thus, while some studies (e.g. Stotsky, 2006; Vingsle, 2014; Chowdhary, Liu, Yerrick, Smith & Grant, 2014; Avraamidou, 2014) give insights into Science teaching and the types of knowledge that Science teachers and beginning Science teachers should possess, there is a general lack of research on what knowledge and skills Science teacher educators need for their work. Research is central in shaping teacher educators' professional knowledge and standards; one cannot learn about instructing teachers on how to teach without research (Loughran, 2014). Such research observations constitute compelling evidence for the need of a study of this nature. Loughran (2014) posits that teacher education is complex; involving curriculum, pedagogy and research. Teacher educators' development of new forms of knowledge and skills is greatly enhanced through rigorous research activities on their work, and the teacher educators must be able to model how their practice is informed by, and responsive to research knowledge.

Loughran (2014) contends that there are several issues that are crucial for a pedagogy of teacher education; namely, a serious focus on pedagogy; conceptualizing teaching as problematic; making the tacit nature of practice explicit; articulating the principles of practice, collaborative enquiry and a concern for the knowledge and practices related to the ways student teachers learn and develop through experience in their course programmes. An analysis of these issues suggests that teacher education is turning its focus towards knowledge of the learner, teaching / learning contexts, educational theory, pedagogy and collaborative research on the best ways of developing effective teaching force.

A recent study by Porayska-Pomsta 2016) provides alternative frameworks to think about teaching and learning in teacher education. This study holds the view that the field of teacher education is undergoing change from a predominant focus on knowledge for teaching towards specifying teaching practices that entail pedagogic know-how and practice. McDonald, Kazemi and Schneider-Kavanagh (2013) highlight core practices for teaching which educators need to know. On the list of such practices are: practices that occur frequently in teaching; practices that novices can enact in classrooms across different curricula or instructional approaches, practices that beginning teacher educators can actually begin to master, practices that allow novices to learn more about students and about teaching, practices that preserve the integrity and complexity of teaching and practices that are research-based and have the potential to improve student teacher learning.

In order to implement the seven core practices, teacher educators need a common language and identified pedagogies based on knowledge of: instructional goals, students, and the integrity of the discipline (McDonald et al., 2013). McDonald et al.'s (2013) ideas are significant because they provide a framework for teacher education pedagogy, which offers a model for engagement in authentic instructional activity. In the writers' view, it is high time that knowledge and skills for science teacher educators become explicit knowledge that can be useful in higher education curriculum and by those wishing to join the profession. The body of research in the area (e.g. Wilson, 2006; Berry & Van Driel, 2012; Loughran, 2013; Goodwin et al., 2014; Kelemen, 2015; Ping, Schellings, & Beijaard, 2018; Rusznyak, 2018) thus, laments the absence of such codified knowledge. It is against this backdrop that the present study was undertaken to examine professional knowledge standards for Science teacher educators in two Zimbabwean Teachers' Colleges. The ultimate aim of this study, is thus to improve the quality of Science teachers through effective teacher preparation.

STATEMENT OF THE PROBLEM

A standard knowledge base for science teacher educators is a requirement for the development of a sound Science teacher education. Possession of such knowledge and skills will enable the science teacher educators to specify practices that entail pedagogic know-how and assist the development of a set of knowledge practices or codified knowledge. However, research (e.g. Wilson, 2006; BerryVan Driel, 2012; Loughran, 2013; Goodwin et al., 2014; Rusznyak, 2018) has shown such knowledge to be largely missing in Science teacher education; hence, the present study sought to examine the professional knowledge standards of the Science teacher educators from the perspectives of both the Science teacher educators and Science student teachers.

RESEARCH QUESTIONS

The following research questions guided the present study.

a) What professional knowledge standards are Science teacher educators expected to possess?

b) What relevant Science teaching knowledge and skills do science teacher educators impart to science student teachers in order to prepare them for effective Science teaching?

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c) To what extent is research used to generate knowledge for Science teacher education?

METHODOLOGY

Research paradigm

The current study is located in the post-positivist paradigm. The paradigm is characterized by its emphasis on meaning-making and creation of new knowledge, integration of theory with practice, and a balance of personal views of the researcher with professional and theoretical viewpoints (Ryan, 2006 & Henderson, 2011). The paradigm allowed the use of the mixed methods approach in collecting and analyzing data. Creswell (2014 p. 32) says; "Mixed methods research is an approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks". For Johnson and Christensen (2012), this triangulation of quantitative and qualitative approaches does not only result in the collection of multiple kinds of data but also in comparing and validating data collected through different ways. For these reasons, the present researchers found the paradigm to be very appropriate for the study.

Research design

The study adopted a sequential explanatory mixed methods design. Quantitative and qualitative data were collected in a sequence, with qualitative data largely used to validate and cross-check observations made through quantitative data. Thus, this design had the advantage of permitting the triangulation of different data collecting instruments.

Participants

This study involved final year science student teachers (n=108) obtained through purposive random sampling and all the science teacher educators(n=18) in the two secondary school Teachers' Colleges (COL-A & COL-B). The sample of science student teachers (n=108) was representative, given that the student population was 1. Thus, the student sample represented 10% and according to Van Dalen (2000), in descriptive research (which this study is), anything from 10% to 20% of the population is representative. Given that all the Science teacher educators in the two colleges were involved, their sample was representative. For Creswell (2007), careful sampling of participants improves the validity of research results while a representative sample enhances the credibility of research results. Thus, purposive random sampling helped to achieve breadth and in-depth coverage of the study by focusing on a representative sample and on information-rich participants purposively selected from the two colleges.

Methods of Data Collection

Data were collected through a semi-structured questionnaire, follow-up interviews, focus group discussions and documents. The semi-structured questionnaires, which contained open and closed – ended items, collected both quantitative and qualitative data from science teacher educators and science student teachers. The non-imposing open-ended items allowed the hearing of the participants' views as much as possible but of course within the confines of the research design. On the other hand, closed items were useful in generating mean scores that were statistically treated and reported in percentages.

Follow-up interviews, which were conducted after an initial analysis of results from the science teacher educators' questionnaire, were meant to probe into subtle issues and to have obscure and unexpected responses clarified. These interviews also helped the researchers to see the motivations of the science teacher educators and their reasons for responding the way they did. Focus group discussions instead of interviews were used with the science student teachers because of their large numbers. However, the focus group discussions were used for the same purpose as the follow-up interviews. Documents such as science teacher educators' teaching plans, syllabi, mark profiles and science student teachers' schemes of work, lesson plans, lecture notes and Teaching Practice files were analysed and yielded qualitative data. While some of the qualitative data were categorised into themes and analysed accordingly, other qualitative data were used to buttress/ refute observations made through the questionnaire.

Validity and reliability of the questionnaire

The validity and reliability of the questionnaire were tested through the inter-rater method. This involved giving the questionnaire to experts in the field of Teacher Education. The experts were requested to check the questionnaire for suitability / validity and to rate it (out of 10 as a measure of people's perspectives. All the 6 experts agreed that the questionnaire was suitable / valid. For reliability, the ratings were correlated and an inter-rater reliability co-efficient of 0.77 was yielded, indicating that to a very high degree, the raters agreed that the questionnaire was very reliable.

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Trustworthiness and credibility of qualitative data

The trustworthiness and credibility of qualitative data from focus group discussions and document analysis was ensured through member-checking, prolonged engagement in the field and through triangulation of different data collecting instruments.

FINDINGS AND DISCUSSION

The findings and their discussion were presented as per headings generated from the research questions. Science teacher educators' knowledge and skills for science teaching in COL-A The first research question sought to identify professional knowledge standards that teacher educators are expected to possess. Precisely the question sought relevant Science teaching knowledge and skills that Science teacher educators should have so that they can appropriately impart these to science student teachers in order to prepare them for effective Science teaching. Table 1 shows mean scores, expressed as a percentage (%) pertaining to the Science teacher educators' knowledge and skills for science teaching as perceived by the educators themselves and their science student teachers (SSTs).

Table 1: Mean scores (%) pertaining to science teacher educators' (STEs) and science student teachers' (SSTs) knowledge and skills for science teaching (n=10; 59).

Questionnaire variable	**STEs' Mean Score (%)**	**SSTs' Mean Score (%)**
Teaching is more hands-on than text-book driven	82	80
Teaching offers adequate content rigour	92	82
Content is transformed into learnable experiences	88	82
Students are skilled in practical ways to handle large classes	82	78
STEs had adequate knowledge on the nature of Science	96	86
STEs engaged SSTs in lab-based practice	92	82
Specific teaching strategies for particular topics were offered to SSTs	90	80
STEs exemplified how to teach by modelling exemplar teaching	88	78
STEs' teaching demonstrated involvement in research	70	70

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The results from Table 1 show that the STEs felt that their teaching offered enough content rigour (92%), and that they engaged SSTs in laboratory-based practice (92%). The two aspects of the STEs' practice in science teacher education got relatively high scores. There was a general agreement noted between the STEs' responses and the SSTs' responses, although all SSTs' mean scores were lower on each questionnaire variable. Asked to judge their STEs' knowledge and skills for science teaching, the SSTs agreed that the STEs had considerable skills to transform content into learnable experiences (82%), content rigour (82%) and that the STEs engaged them in lab-based practice (82%). Data gathered in follow-up interviews and focus group discussions seemed to confirm the importance that was placed on teaching that offered enough content rigour and the practice of engaging SSTs in laboratory-based practical work. All the four interviewed STEs underscored the importance of content rigour. The interviewees seemed to suggest that, in part, content rigour was enhanced by engaging the SSTs in laboratory-based practical work. The findings confirmed what other studies (Anneta & Dotger, 2006; Balland Forzani, 2008; Rollnick, Bennet, Rhemtula, Dharsey& Ndlovu, 2008; Kriek& Grayson, 2009; Miller, Ohana & Hanley, 2013; Borgeding et al., 2015) have said on the importance of subject matter knowledge (SMK) for any teaching endevour to be successful. According to Ball and Forzani (2008), content knowledge defines teaching as a profession. A teacher with limited content knowledge lacks in confidence. Miller et al. (2013) identified content knowledge as one of the key infrastructural components of a successful Science teacher preparation programme.

Skills in conducting practical work in science was the other aspect that was considered valuable to a Science Teacher Educator's repertoire. The STEs argued that some problem-solving skills developed out of the practice of engaging SSTs in science practical work. Thus, for the STEs, skills on how to carry out scientific investigations were considered as core to the development of science teachers. The weight given to the need to develop SSTs' prowess in science practical skills was confirmed through the data gathered from documents. The Post 'O' Level Chemistry syllabus that was currently in use indicated, in its assessment scheme section, that a minimum of two assignments, two tests and four practical exercises would be used. The final academic examining mark profiles for 2013, 2014, 2015 and 2016 agreed largely that STEs were following syllabus requirements. The 2013 profile showed that 4 major practical exercises were done (1 Biology, 1 Physics, and 2 Chemistry) and the 2014 one, revealed that 3 practical exercises were done (1 Biology, 1 Physics, and 1 Chemistry), while the 2015 and 2016 profiles showed a repeat of the 2013 work. The emphasis on science practical work portrayed in the respondents' documentation was in tandem with one of the requirements of Zimbabwe's then Ministry of Science and Technology Development, Report (2012) on science teaching. The report notes that the first goal on strengthening capacity development in Science, Technology and Innovation (STI) relates to having Science subjects taught in ways that allow pupils to undertake direct practical experiments regularly as Science laboratory work. In line with Hattingh, Aldousand Rogan's (2007) definition, science laboratory work consisted of the learning experiences in which learners interacted with materials, objects, research and scientific ideas, technology, peers and themselves, through the process of metacognition in order to understand phenomena.

Although the SSTs, in COL-A, acknowledged the existence of some practical components in their work, they thought that their teachers were not doing enough to develop them fully in science practical work. As part of their concerns, they lamented limited real-world problem-solving, lack of variety in approaches to practical work, limited time for the practical work, limited pedagogic content knowledge, lack of knowledge of the secondary schools' new curriculum, and inadequate assistance in conducting the practical exercises. As part of these sentiments, SST9, said:

I think since we are dealing with the issue of hands-on in this college, the teacher who is trained here is supposed to use the hands-on approach when they go out in schools, but here in college, we are not given the skills on hands-on teaching yet that is where it should start. So, it becomes difficult when you are in schools. Usually it will be theory. The lecturers should be very practical, so that when we go out there, there will be no challenges.

SST13 added: We do practical work but it seems inadequate because if we look at our situation, we have one day per week for practical work yet the newly introduced curriculum in the secondary schools requires teachers to engage learners a lot in practical work, of which you, the teacher, are not given that time to do practical work, which means when I am now in the field, I will not have the willingness to engage in those practicals, but will focus on theory instead of practical work.

The SSTs' sentiments raised concerns that other research findings have noted. Motlhabane (2013) observed the unsatisfactory conditions for doing practical work in Science subjects in secondary schools, in South Africa.

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Motlhabane's (2013) study noted that, because many learners do practical work for the first time at higher levels without having had the proper training and background for doing practical work, they face challenges when learning Science is mainly done through practical experiments. Motlhabane's (2013) study points to the need to assist students in the process of conducting scientific investigations, in order for them to reflect on their previous experiences and see the experiences in practice, as suggested by Nivalainen, Asikainen and Hirvonen (2013). In another study, Matorevhu (2016) observed weak science pedagogical content knowledge on science pre-service teachers studying with one university in Zimbabwe. Mandina's (2017) study in Zimbabwe, reports the use of didactic and theoretical approaches to science practical work, insufficient time allocation for the work and ill-prepared teachers. Kapenda, Kandijeo-Marenga, Kasandra, & Lubben, (2002) explored characteristics of practical work in science classrooms in Namibia. Kapenda et al. (2002) provided substantial evidence showing that most practical activities in science classrooms or laboratories are ill- conceived, confusing, time wasting and unproductive; providing little educational value to the learner. Findings from Kapenda et al.'s (2002) research showed a limited view, by the teachers, of the aim of practicals. What is apparent from this discussion is that the process of conducting practical work in science is still fraught with challenges that science teacher education needs to scrutinize closely, through further research. The research may focus on how STEs can refine their skills in conducting practical work that engages all the SSTs despite their diverse academic backgrounds.

The findings in Table 1 also show high mean scores for STEs' knowledge on the nature of science (96%), STEs' ability to: (i) transform content into learnable experiences (88%) and (ii) offer to SSTs specific teaching strategies for particular topics (90%). The nature of science is a concept usually taken to insinuate the process of science and methods employed in the collection, analysis, synthesis and evaluation of evidence and the subjective character of scientific knowledge (Stefanidou & Skordoulis: 2014), while the transformation of content into learnable experiences through specific teaching strategies is a concept enshrined in pedagogic content knowledge (Mavhunga & Rollnick, 2016). From the questionnaire responses, the STEs thought that they had adequate knowledge of these two concepts. While the SSTs agreed to (i) and (ii) above in their responses to the same issues, the mean scores were lower than those awarded by the STEs themselves. In the SSTs' judgment, STEs' knowledge on the nature of science, ability to transform content into learnable experiences and their ability to offer SSTs specific teaching strategies for particular topics was rated at 86%, 82% and 80% respectively. The finding that STEs' had sufficient knowledge on the nature of science, is not confirmed anywhere in science teacher education, in Zimbabwe but rather in high school science teaching in the same country, by Vhurumuku (2015). In Vhurumuku's (2015) study, high school Chemistry teachers' scientific epistemologies on selected aspects of nature of science and nature of scientific inquiry were elicited through semi-structured interviews. Vhurumuku (2015p.196)

says: The findings reveal that the manifestation of a teacher's scientific epistemologies into laboratory work instructional practice is complex, and governed by factors in the instructional environment as well as other beliefs embedded within the teacher's conceptual ecological system. It is argued that the translation of a teacher's beliefs into practice is a conscious activity during which the teacher weighs and balances cognitive and epistemic factors and makes judgmental decisions about the merits and demerits of instructional action.

Vhurumuku's (2015) conclusion on his findings that teachers put their scientific epistemologies into practice, but only to a small extent, probably meant that, while the STEs in COL-A knew about the demands and importance of the nature of science and pedagogic content knowledge, as indicated by the high mean scores, they rarely applied the two concepts in practice. The assertion that a science teacher's knowledge about some scientific epistemologies does not translate into practice, as articulated in Vhurumuku's (2015) study, was confirmed in the respondents' documents.

An analysis of the subject syllabi showed that the department had revised their syllabi to four separate entities of Biology, Physics, Chemistry and the Methods Course. Previously, the four were housed in a 2006 single syllabus, which worked up to 2013. The researcher was interested to find out what additional knowledge and skills were brought about by the revision of the syllabus, particularly the Methods Course one. It was found that the old methods course curriculum was more detailed than the revised one, currently in use. Although topics such as the nature of science, history of science, structure of syllabus, syllabus interpretation, and few others were retained, important areas in science teaching such as science teaching and gender, philosophy of science, HIV and AIDS, health-related issues, religion and language in science learning, and the concept pedagogic content

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knowledge were left out in the new syllabus. This finding ran contrary to expectations, since detailed science methods courses are pivotal to secondary science teachers' development

(Sickel & Witzig, 2017). Reviewing the importance of comprehensive science methods, Sickel and Witzig (2017 p. 2) say: Science methods courses act as the bridge between many areas of the teacher education curriculum, as well as between education and studies in the science departments. Methods courses help prospective teachers to integrate knowledge and gain experience in applying this integrated learning in actual school settings with real students or in simulated environments with peers.

Furthermore, a perusal of the SSTs' lecture notes found in their coursework files submitted as work samples for external academic examination confirmed the observation that the new revised syllabus was shallower than the previous one. There was no content found as lecture notes on the nature of science, history and philosophy of science despite the inclusion of these concepts in the syllabus. It is possible the omission was due to other reasons such as lack of time to cover the syllabus. However, one possible reason for the omission of certain content areas of a syllabus in the actual teaching was perhaps the view that the STEs had limited knowledge in these areas, and consequently were not comfortable teaching the concepts. In line with the view that STEs sometimes have limited knowledge in these areas, Krogh and Nielsen (2013) found that there was a large gap between academic knowledge about the history and philosophy of science, and the nature of science knowledge enacted and learned in classrooms.

According to Maringe (2005 p.13), "…philosophy of science is recognised as the key contribution to the transformation of science teacher education and must constitute a central focus in science teacher preparation programmes". The importance of equipping pre-service student teachers with knowledge on the nature of science cannot therefore, be under-estimated (Maringe, 2005). Furthermore, the philosophy and history of science teacher education was considered a launching pad for the development of logic and critical thought in science student teachers (Matthews, 1997; Berkel, 2015). Also highlighting the central role of nature of science, Stefanidou and Skordoulis (2014 p.183) say; "Nature of Science constitutes an integral part of the scientific literacy that science education aims to impart to both students and teachers". According to Stefanidou and Skordoulis (2014), an understanding of the nature of science would give the SSTs the threshold to think scientifically, use scientific knowledge in problem-solving and acquire knowledge of what counted as science, the scientific process and knowledge on the objective and subjective character of science. In the same vein, Loughran, Mulhall and Berry (2008) concluded in their study that, through their familiarity with the notion of pedagogic content knowledge, undergraduate students' way of talking about science teaching and learning seemed somehow different, in a positive way, from that of their colleagues unfamiliar with the notion of pedagogic content knowledge. Thus, introducing student teachers to the ideas of pedagogic content knowledge through training becomes an additional way to support student teachers' preparation for science teaching.

Science teacher educators' knowledge and skills for science teaching in COL-B. In line with the study's first sub-research question, it was also important to find out the knowledge and skills for science teaching COL-B STEs had. The SSTs' questionnaire sought their perspectives on Science Teacher Educators' knowledge and skills for science teaching. Table 2 below shows the mean scores (%) for the STEs and SSTs on knowledge and skills for science teaching.

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Table 2: The mean scores (%) for the STEs and SSTs on knowledge and skills for science teaching (n= 8; 47).

Questionnaire variable	STEs' Mean Score (%)	SSTs' Mean Score (%)
Teaching is more hands-on than text-book driven	72	74
Teaching offers adequate content rigour	78	74
Content is transformed into learnable experiences	72	82
Student are skilled in practical ways to handle large classes	80	72
STEs had adequate knowledge on the nature of science	98	82
STEs engaged SSTs in lab-based practice	88	84
Specific teaching strategies for particular topics were taught to SSTs	88	78
STEs exemplified how to teach by modelling exemplar teaching	88	82
STEs' teaching demonstrated involvement in research	72	80

Although the SSTs agreed (with a mean score of 80%) that the STEs' teaching demonstrated involvement in research, the STEs themselves had a moderate opinion about the same aspect, with an agreement rate of 72%. This may suggest that the STEs' involvement in research was not up to a level they desired. The result tallied with Weiler's (2001) observations on one teacher's college in Zimbabwe. Weiler (2001 p.414) says:

The faculty at BTTC did not need someone from the outside the college to come and tell them that there were problems with the CDS. There was consensus throughout the college that the CDS was not living up to its potential, stated in the Belvedere Technical Teachers, College: Applied Education Syllabus.

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Although the SSTs agreed (with a mean score of 80%) that the STEs' teaching demonstrated involvement in research, the STEs themselves had a moderate opinion about the same aspect, with an agreement rate of 72%. This may suggest that the STEs' involvement in research was not up to a level they desired. The result tallied with Weiler's (2001) observations on one teacher's college in Zimbabwe. Weiler (2001 p.414) says:

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Curriculum Depth Study (CDS) is the name given to student teachers' research projects in Teacher Education Colleges in Zimbabwe (UZ-DTE, 2015). Table 2 also shows that the STEs thought that they had sufficient knowledge on the nature of science (98%), specific teaching strategies for particular topics (88%), lab-based practice (88%) and modeling exemplar teaching (88%).

However, their students rated them high on engagement of SSTs in lab-based practice (84%), modeling exemplar teaching (82%), knowledge on the nature of science (82%) and their ability to transform content into learnable experiences (82%). The two groups seemed to concur that laboratory-based practice, modeling of exemplar teaching and knowledge on the nature of science constituted an important part of any STEs' repertoire, and therefore, the three aspects were crucial to science teacher education. Various studies have also confirmed the importance of laboratory-based practice (Bhukuvhani et al., 2012; Kibirige et al., 2014; Haifa, 2016), modeling exemplar teaching (Sickel & Witzig, 2017) and the nature of science (Matthews, 1997; Krogh & Nielsen, 2013; Stefanidou & Skordoulis, 2014; Berkel; 2015), to science teacher preparation.

Data from the documents confirmed the first two, that is, the aspects of laboratory-based practice and modeling of exemplar teaching. The STEs' Teaching programmes, the SSTs' lecture notes and assessment items showed that a lot of practical work was covered. For instance, the department's 2014 Teaching programme for the 3-3-3 finalist group showed that in Chemistry, experiments on chemical bonding, redox reactions and chemical equilibrium had been done. In agreement with the literature on science practical work (Bhukuvhani et al., 2012; Kibirige et al., 2014; Haifa, 2016), the Methods Course teaching programme indicated that practical work would be done for three successive weeks without specifying what the practical work was about. However, this finding contrasted with what was discovered in COL-A concerning the quantity and frequency of practical laboratory work. What emerged here, in the practice and voices of the observed STEs and SSTs in COL-B, was that laboratory practice was given prominence. It also meant the STEs modeled exemplar teaching because science is a practical subject that requires concepts to be presented through investigations, projects and other laboratory practices. It was not clear if the subject on the nature of science received adequate treatment because the syllabus had aspects of nature of science in disjointed form. There was both a paradox here. At one level, the STEs indicted very limited knowledge on nature of science. Document observation and analysis showed the syllabus had aspects of nature of science in disjointed form. At the same time, the SSTs were articulate on nature of science, as well as the history and philosophy of science. Asked if they ever taught content on nature of science, the history and philosophy of science,

STE6 said:Not really. It is just something that comes coincidentally as we teach.

STE7 said: Oh, yes! We cover that one. The history of science is also in Biology. The history of cells, but not much. However, the SSTs seemed to have some awareness on the nature of science. The following excerpt illustrates the point.

Researcher: Do you think it would be important to learn about the nature, history or philosophy of science?

SST19: Yes, it is very important because it helps us to be critical thinkers, as we learn how other science philosophers worked to come up with innovations in science.

SST23: It gives knowledge about where science came from.

SST22: You appreciate the presence in science, how it came about.

The responses from the SSTs show that they were conscious of aspects to do with nature of science, philosophy and history of Science. What seems undeniable, however, was that the treatment of the issues on nature of science, the history and philosophy of science in COL-B was coincidental rather than deliberate. This finding and the other one that the STEs were not adequately satisfied with their own involvement in research, was a cause for concern, given the nature of knowledge and skills that a Science Teacher Educator should possess. Findings from Goodwin et al.'s (2014) survey reveal that teacher educators should have theoretical knowledge, possess ability to apply theory, be grounded in content knowledge, be knowledgeable about science in its various forms, be familiar with research approaches and be able to conduct research, possess interpersonal and reflective skills and use multiple modes and materials for teaching such as multimedia materials, cases, micro-teaching, field experiences and lesson study. Goodwin et al.'s (2014) study ties with the current one on the assertion that a teacher educator needs to be knowledgeable and skilled in a number of areas inclusive of research and knowledge areas that define the science subject; such as nature of science, history and philosophy of science.

CONCLUSION

The teacher educators in this study engaged their trainees in laboratory-based practice and, to some extent, integrated their teaching with ICT. Student teachers from the two colleges (COL-A & COL-B) seemed to concur that laboratory-based practice, modeling of exemplar teaching and knowledge on the nature of science constituted an important part of a science teacher educator's repertoire, and therefore, the three aspects were crucial to science teacher education. Laboratory-based practice was however, a challenge with some student teachers, who felt their academic background in the secondary school, had not equipped them with enough skills and knowledge for such practice. What is clear from this study is that the process of conducting practical work in science is still fraught with challenges that science teacher education needs to scrutinize closely, through further research.

Despite the lack of clarity from this study if the science teacher educators used knowledge on the history and philosophy of science and the nature of science, these three aspects of science pedagogy remain a crucial part of science teacher education, which all Methods Courses need to embrace.

The other aspect that was considered vital for science teacher education by student teachers and science teacher educators alike, in both colleges, was the ability to utilize science pedagogy that is research-based. However, despite the importance placed on research-based practices by many scholars (Miller et al., 2013; Loughran, 2014; Goodwin et al., 2014; Porayska-Pomsta, 2016), the science teacher educators in this study engaged in limited research activity. The view that they engaged in limited research activity meant their teaching approaches were not research-based and resultantly, the creation of new science teaching knowledge and novel instructional approaches was greatly compromised. The researcher felt this was a worrisome result because, in line with Goodwin et al.'s (2014) thinking, teacher educators should have the ability to apply theory, be grounded in content knowledge, be familiar with research approaches, and be able to conduct research in order to improve their own practice. According to a model by Loughran (2014), effective curriculum implementation is a product of two types of knowledge; knowledge and practice of teaching about teaching and knowledge and practice of learning about teaching. The successful implementation of the latter is only possible through research. One cannot learn about teaching how to teach without research.

Consequently, the absence of research-based science teaching knowledge meant the sustainability of science teaching approaches that are reform-based and their incorporation into science pedagogy was in question.

Teacher educators should have theoretical knowledge, possess ability to apply theory, be grounded in content knowledge, knowledgeable about science in its various forms, be familiar with research approaches be and be able to conduct research, possess interpersonal and reflective skills and use multiple modes and materials for teaching such as multimedia materials, cases, micro-teaching, field experiences and lesson study.

Recommendations based on the findings of the study

Based on the above findings and conclusions, the following recommendations are made:

- Science teacher educators need to refresh their knowledge and skills for Science teaching through engagement in active research. Research-based pedagogy ensures sustainable development of reform-based science pedagogy and the growth of scholarship in science teacher education.
- Science teacher educators need to deliberately infuse a diverse knowledge base inclusive of the history, philosophy and the nature of science in their teaching and pedagogy

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THE REALITY AND RHETORIC OF RIGHTS-BASED APPROACHES TO DEVELOPMENT

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ABSTRACT

The study sought to determine the appropriateness and effectiveness of Rights-Based Approaches (RBAs) as an overarching framework for sustainable poverty reduction and development. This involved assessing the practical impact of RBAs, implementation of RBA strategies as well as identification of key variables for successful rights-based development, premised on the understanding of poverty as an outcome of structural inequalities consistent with human rights violations. The descriptive survey was underpinned by a pragmatism research philosophy employing a mixed methods approach with a largely qualitative concurrent embedded strategy. Data were collected through interviews, observations and focus group discussions and participants were selected using probability and non-probability sampling methods. The study highlighted that poverty was still largely defined from the basic needs and income perspectives, and attributed to individual deficiencies. It also highlighted that understanding of RBAs was weak and that governance issues with respect to development processes were largely driven by development partners. The RBAs are compatible with endogenous discourses and appropriate but have not been effective largely due to their weak implementation rather than their design. The government has not been effective in its oversight role. NGOs, however, have not transformed themselves to operate as equal development partners. The study recommends that clear indicators for rights-based development must be developed and development processes must focus on confronting inequalities guided by human rights and RBA principles. NGOs should transform themselves into 'corporations of the poor' and the government must be at the centre of the development enterprise.

***Key Words**: Human Rights, Poverty, Inequality*

INTRODUCTION

The past two decades have witnessed pronounced erudite understanding of poverty resulting in the generation of an overlapping but firm consensus on what poverty entails. As a result, it is now generally agreed that poverty is multi-dimensional in nature and is a human rights violation that arises mainly from power gradients or structural inequalities. Over the supervening years, the search for a holy grail for poverty reduction saw the crafting and deployment of Rights-based Approaches (RBAs) on the development landscape largely promoted by NGOs, with expressed reservations from governments in the global south. In spite of this, and a marked increase in development resources as well as increased number and visibility of development players, sadly and worryingly, poverty remains robustly sustainable. The RBAs have been around for more than a decade now but their impact on poverty reduction and development in communities is not well documented. While they (RBAs) have gained currency globally, literature is overstocked with divergent opinions including scepticism, raising questions on their effectiveness and contextual appropriateness, or adequate conceptual understanding or full embracement in practice (Kindornay et al., 2012). Skepticism is justified given ongoing concern over poverty dynamics in rural Zimbabwe and elsewhere.

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An Overview of Global Poverty Dynamics

Poverty is undeniably a global reality with a long intellectual history (Woolcock, 2009), and is the greatest and gravest human rights challenge facing global society today (Chen & Ravallion, 2008). Many communities across the globe are facing a largely uncontested and saddening reality of a glaring and growing hiatus between the rich and the poor (Mpofu, 2011). An estimated one fifth of the global population, what Paul Collier calls the bottom billion, live in absolute poverty (Collier, 2007). The majority of these are marginalised women averagely estimated to be about 70%. Alarmed by this fact the United Nations Development Programme (UNDP), in its 1995 Human Development Report (HDR) remarked that "poverty has a woman's face" and unless human development is engendered it (human development) is endangered (Hemmati and Gardiner, 2002:15). Rural poverty, largely afflicting the global south (developing countries), is estimated to be around 63%, "reaching 90% in countries like China and Bangladesh and ranges from 65% and 90% in sub-Saharan Africa" (Khan, 2006:6). Consequently, it is not surprising that "poverty reduction is at the core of development policy-making and a key commitment of donor agencies" (Francis, 2006:1).

Globally, the last two decades have witnessed a general slump in the performance of many economies especially those in developing countries. It is also generally agreed that poverty and some of the challenges facing these economies result from structural distortions (Chigumira and Chizema, 2011) that are essentially binding constraints. The search for lasting solutions to these challenges has seen a variety of policies and strategies being crafted and deployed. Such solutions include policy reforms championed by the policy orthodox of what Williamson dubbed the Washington Consensus, a consensus on the reforms that arose among their Washington based proponents (World Bank, IMF and US Treasury), emphasising economic growth through globalisation and deregulation (Derksen and Verhallen, 2008; Kanyenze, 2011; Sobhan, 2006).

"Implicit in the Washington Consensus was a structural approach to poverty alleviation based on both enhancing the returns that poor households earn on their assets, and facilitating their accumulation of productive assets" (Carter and Barrett, 2005:2). However, the structural adjustment reforms were largely unsuccessful and had numerous poverty-inducing upshots in poorest countries (Hickey and Du Toit, 2007). These effects later haunted the global north (developed countries) as evidenced by marked food prices as well liquidity crunches that had largely transitory impressions on their poverty dynamics but regrettably had severe sways in the global south - increasing the vulnerability of the populations inevitably, plunging many into poverty entrapment (Hulme and Shepherd, 2003; Kanyenze, 2011).

The structural adjustment programs (SAPs) were later dumped amid a lot of apprehension and resultantly, (Rodrik 2006) cynically titled his review work (of the SAPs): "Goodbye Washington Consensus, Hello Washington Confusion." He observed that some countries that did not embrace the reforms had recorded economic headway during the duration of reforms (Chigumira and Chizema, 2011; Kanyenze et al, 2011). The reforms were followed by the Poverty Reduction Strategy Papers (PRSP) which emphasised increased focus on poverty by governments and other partners (Kanyenze, 2011), and were criticised mainly for failing to capture the needs and rights of indigenous populations (Hickey and Du Toit, 2007). In addition, the PRSP were perceived as "simply delivering repackaged structural adjustment programmes" and not conveying participatory and poverty focussed development (Ruggeri-Laderchi et al., 2003:261).

During all this time, the development landscape witnessed the emergence of Non-Governmental Organisations (NGOs) across the globe - established fundamentally to respond to increasing poverty levels and marked failure by governments to deal with the poverty challenge (Brinkerhoff et al., 2007; Stromquist, 2002). The donor community also increasingly got organised and sturdier as evinced by enhanced coordination and the creation of consolidated funding

mechanisms like the Global Fund, resultantly having more sway on the development panorama.

Poverty Trajectory in Zimbabwe

On the local scene, the poverty trajectory followed almost a similar path. Prior to the deployment of the SAPs during the Independence decade (1980-1990), the country had adopted a socialist economic model, heavily investing in the social sector buoyed by a, "relatively developed and diversified economy by African standards," it had inherited (Kanyenze, 2011:4). The economy, described by the late Tanzanian President, Julius Nyerere, as 'the jewel in Africa' was based on white supremacy with inherent structural inequalities. Nyerere's remarks summarised the 'enclave' of the economy (an 'enclave' with a secluded and distinct formal sector) which overshadowed a dual economy formally employing about a fifth of the total labour force, mainly men, leaving out roughly 70% of the black population to rely on a female dominated, archaic, undeveloped and fundamentally rural economy with limited sustainable livelihoods such as land.

Soon after the Independence decade, the country embarked on the Economic Structural Adjustment Programme (ESAP) (1991-1996) embracing market economics following this with a highly noble but poorly directed land reform programme which resulted in adverse results punctuated by negative growth (Chigumira and Chizema, 2011; Kanyenze, 2011; Kinsey, 2010), resultantly rendering poverty reduction, without positive economic growth, impossible (Khan, 2001). The economic slump was also accelerated by the payment of unbudgeted gratuities to Liberation War fighters in 1997, the country's participation in the Democratic Republic of Congo (DRC) war in 1998, droughts (1991/1992, 1994/1995, 1997/1998, 2001/2002), political instability, outbreaks of water borne diseases such as cholera, prevalence of HIV and AIDS (Kanyenze, 2011), the collapse of the trade agreement with South Africa in the mid-1990s, unsustainable exchange control; steep decline in gold prices and prices of the country's main export crops (cotton and tobacco) and reduced investor confidence as a result of lack of transparency of land reform policies (Kinsey, 2010) as well as weakening rule of law and poor governance (Bird and Prowse, 2008). The country also hopped from one home grown economic model to another in pursuit of the evasive growth following the failure of both the SAPs further complicating the situation (Kanyenze, 2011).

These events led to a serious crisis that generated into paralysis only to be corrected after September 2008 after the signing of the Global Political Agreement by three main political enemy parties. At the height of the crisis, structural unemployment levels reached 80%, growth fell to a record negative 14.8%, 'the fastest shrinking economy' according to Bird and Prowse (2008) and inflation reached an unparalleled official figure of 231million percent, argued by independent analysts by mid-November 2008, to be about 79,600,000,000 percent monthly converting to a daily rate of 98% and annually to 89.7 sextillion percent. Inequality measured by the Gini coefficient worsened increasing to 0.61 by 2003 from 0.53 in 1995 (Kanyenze, 2011). Poverty levels increased to 1957 levels and the country's 2010 HDI index (at 0.140) was 25% lower than what it was in 1970 (UNDP, 2010).

In Zimbabwe, poverty is devastatingly rural (77% of the poor live in rural areas) and is concentrated in the communal farming areas that are home to half the population "but three-quarters of the poor and over 80 percent of the very poor" (Kinsey, 2010:5). At the peak of the economic crisis in 2008, over 85% of the population was classified as poor (Bird and Prowse, 2008) and by April 2010, Mpofu (2011) citing UNICEF, noted that 78% of the population was absolutely poor and the country was regarded as a 'factory of poverty.' The Zimbabwe National Statistics Agency (ZIMSTAT), citing its Poverty Income Consumption and Expenditure Survey (PICES) results for the 2011/2012 period, and based on money-metric approaches (income and consumption) of measuring wellbeing, estimated that 76% of rural households were poor and 30.4% were extremely poor. The PICES results also showed that poverty is predominantly rural with the two urban

provinces (Harare and Bulawayo) having the lowest percentages of poor people (ZIMSTAT, 2013).

Understanding Poverty, Inequality and RBAs

Poverty is multidimensional (Pogge & Rippin, 2013) and largely a rural phenomenon (Chigumira & Chizema, 2011; Suharko, 2007; Zimbabwe National Statistics Agency [ZIMSTAT], 2013). While the existence of poverty in society is an incontestable fact, its definition and understanding are still characterized by a lot of debate albeit increasingly with reduced divergence. Over the intervening years common ground on the broad areas that define poverty has been established.

Empirical evidence from the "Voices of the Poor study" undertaken in over 47 countries in 1999 for the World Bank's World Development Report 2000/2001 titled "Attacking Poverty", points out that poverty has to do with vulnerability, deprivations and general low standard of living (wellbeing). The qualitative study concluded that poverty is multidimensional and time is a core dimension of wellbeing and poverty. The poor added diseases and theft as some of the major causes of poverty. Voicelessness and powerlessness are underlying causes of poverty and this arises from structural inequality. The poor also noted that they suffer from dishonour at the hands of state institutions which suggest lack of accountability (Narayan et al., 2000a, 2000b), and again highlighting structural inequalities that help to ratify poverty.

Another study in Papua by Rumbewas (2005) concluded that the poor define poverty as challenges in securing food and assets or livelihoods. The study identified five dimensions of poverty as well as causes of poverty as "physical weakness, isolation, vulnerability, powerlessness and material poverty. Of these five dimensions, material poverty is seen as making the dominant impact on the others," (Rumbewas 2009:311). Political will is essential in all poverty alleviation efforts.

Six main dimensions are currently being used, separately or in any combination, to define poverty. First is the income dimension which is a money-metric measure of poverty which defines the poor as those living below a certain amount of income or expenditure. Inadequate income represents poverty and currently a person whose income is less than US$1 per day is regarded as poor. Expenditure and consumption are used as proxies of income in cases where income is difficult to measure. This perspective is widely used because it is amenable to valid and consistent measurement (Sachs, 2005). The second dimension is the basic needs perspective which measures poverty based on access to basic needs in which case limited or lack of access to basic needs represents poverty. Although it is related to the income dimension, this view emphasizes explicitly addressing the elements of deprivation rather than camouflaging them in measured income. The third perspective is the social exclusion perspective, where isolation or exclusion which may lead to loss of status, recognition, limited or lack of access to resources and humiliation constitutes poverty. Defined by Silver (2007:1) as a "dynamic process of progressive multidimensional rupturing of the 'social bond' at the individual and collective levels," social exclusion creates and perpetuates inequality. Another dimension is the sustainable livelihood perspective which defines the poor as those whose living is inadequate for the satisfaction of basic needs and is insecure against anticipated shocks and stresses (Chambers, 1995). Fifth is the human development perspective and under this view the poor have limited choices and capabilities (opportunities). Finally, the human rights perspective characterises poverty as a human rights violation highlighting that poverty results from structural inequalities. This link was echoed by Everatt (2005:19) who noted that "poverty and inequality are the illegitimate twins inherited by democratic South Africa."

Increasingly there has been a progressive shift from narrow definitions of poverty towards wider issues of well-being and deprivation which is consistent with the human rights perspective. Such a multidimensional view is captured in contemporary definitions floating in development literature today. For example, Zimbabwe National Statistics Agency [ZIMSTATS], (2013: xiii) define poverty as "the inability to attain a level of well-being constituting a realistic minimum as defined by

society." Similarly, the World Bank (2001:15) submitted that poverty is "pronounced deprivation in well-being." The World Health Organisation [WHO] (1995) cited in Hemmati and Gardiner (2002:15) underlined the centrality of wellbeing by describing poverty as "world's deadliest disease."

These definitions of poverty are generally linked to poverty analysis and measurement issues, and the perspectives that define poverty in easily measurable terms have enjoyed frequent usage. Poverty can be classified in terms of duration as either chronic (long duration lasting more than 5 years) or transitory (short term); or in terms of depth and severity either as absolute (below a certain market) or relative (compared to others or an average) (Shepherd, 2007); or in terms of breath/spread either as multi-dimensional (many dimensions) or uni-dimensional. The multi-dimensional view has been well received (Alkire and Santos, 2010).

The human rights perspective treats basic needs as fundamental and legal entitlements that citizens (as rights-holders) can claim from the state and its institutions (duty-bearers) (Boesen & Martin, 2007; Mukhopadhyay, 2004). It argues that poverty is failure by an individual to enjoy their rights which results from failure of the duty-bearer to deliver their correlative duties (obligations) through acts of commission or omission. Rights based Approaches are about incorporating human rights into development activities, and have both normative and procedural features (mindset and ways of doing) (Haigh, 2016). Rights-based approaches are about a rights focus to development that treats development as a right. An RBA focusses on both outcomes and processes of development emphasising building the agency of rights holders in the process of correcting unequal power relations. It focusses on the underlying causes of poverty which are structural inequalities. The human rights perspective views poverty as resulting from inequality (power relations) - how power is exercised. These power gradients dictate how resources and opportunities are distributed and accessed. In essence, voicelessness and powerlessness, and subsequent vulnerability to adverse shocks and inability to respond to those shocks characterize lifestyles of the poor (World Bank, 2001; Narayan, 2005). This highlights the fact that poverty is a human rights issue defined by inequality and this inequality sustains poverty.

There are a number of theories that have been used to explain poverty classified into different taxonomies. Three main dichotomies have been used to categorise these theories viz: individual or community; conservative or liberal/progressive; and cultural or structural. In keeping with the arguments advanced under the human rights perspective of poverty, poverty and inevitably inequality are explained by a group of theories classified as community, liberal/progressive or structural (Bradshaw, 2006). These theories (structural deformities theory, geographical disparities theory, and cumulative and cyclical interdependencies theory) underline structural inequalities as the cause of poverty (Sameti, Esfahani and Haghighi, 2012). These theories do not place the blame of poverty on the individual but on the larger socio-economic and political order (Islam, 2005). Similarly, in this regard, Boesen and Martin (2007:9) insightfully argue that "poverty is never simply the fault of the individual, nor can its solution be purely personal."

The Practice of RBAs

An extensive study, in Guatemala by Plan International (Plan) in 2009 to evaluate its rights-based strategy noted, for Plan, fulfilment of human rights was not its primary mission and was merely using human rights as instruments for analysis and as a guide for program design. Plan was not using the RBA to address the underlying issues of unequal power relations (Bruno-van Vijfeijken et al. 2010). According to Bruno-van Vijfeijken et al. (2010) Plan considered Human Rights and Development as separate notions and did not use human rights as a basis for development action. The study concluded that gradually switching to a rights-based approach to development from a needs-based approach is a contemplative process of change that must certainly impact on all parts of the organization. "Human rights and participation are closely tied. Participation is a right itself, but also a critical tool for people to claim and

exercise their rights… Empowerment through participation is therefore at the heart of RBA," (Bruno-van Vijfeijken et al, 2010:22).

Kindornay et al. (2012) concluded from a study that developing strong NGO-Community relations difficult as was mobilizing communities for their commitment to RBA activities and processes if there were no concrete goods and services. Contrastingly they noted that NGOs that availed direct services found mobilising communities easier. Rights are not easily understood by an average person and are generally associated with the elite or social upper class, they concluded. According to Kindornay et al. (2012), a study commissioned by UNESCO in 2006 concluded that "government and non-government partners [were] largely ignorant of the human rights-based approach . . . [and this was] compounded by the relative lack of familiarity with the approach within agencies themselves" (Kindornay et al., 2012: 22). They noted that many International NGOs had similar experiences and RBAs were largely more rhetorical than real primarily because of lack of clarity on what RBAs entail in both theory and practice. Citing other studies, they noted that knowledge and practice in the development landscape was pitiful and the necessary skills and tools for implementation were lacking. They concluded that "translating rights-based policy into practice is also one of the main problems facing rights-based bilateral agencies. Conceptual confusion over what, precisely, "rights-based thinking" means is one reason that NGOs are encountering dissemination problems (p.22).

Brine (2010) in a Northern Ghana qualitative study observed that there were challenges working with RBAs in whatever context and these include "national sovereignty, the debate over universality of human rights and cultural relativism," Brine, 2010:124). It concluded that participants perceived addressing immediate issues outside the rights discourse as a priority as opposed to associating addressing rights with immediate needs (Brine, 2010). In a qualitative study in Russia Turbine, (2007), concluded that political constraints and cultural norms wedged on the perceived rightfulness of some categories of rights which determines their actions to claim those rights. The study highlighted that RBAs had not resulted in women's empowerment and that the process of claiming rights through recognised legal approaches had demeaning and disempowering effects on women. It underscored the need for a review of assertions about the empowering potential of rights-based approaches (Turbine, 2007).

Another qualitative study by Nyasulu (2009) in Malawi concluded that the perception of the poor as poverty from an economic perspective instead of regarding it as a human rights violation changed following the introduction of RBAs and this was linked to their understanding of rights and rights principles. The poor underscored the need for the poor, disadvantaged and marginalised to actively participate in the design and implementation of poverty alleviation programs. The poor endorsed RBAs underlining that the interventions are effective in alleviating poverty and upholding their rights (Nyasulu, 2009).

A study using Oxfam, CARE International and Amnesty International as case studies, focusing on how impact assessment of RBAs is swayed by the organizations' background, concluded NGOs should work together on impact assessment and must be accountable (Bengtsson, 2007). The study showed that the NGOs were not able to link development to human rights and had largely been unsuccessful in reporting impact in human rights terms. According to Crawford (2007), a study undertaken in Bangladesh, Malawi and Peru revealed that RBA projects had more sustained impact compared to non-RBA projects. The study used a "learning process framework based on the three underlying principles of participation, inclusion and the fulfillment of obligation," (Crawford 2007 : 8). The study established that RBAs deal with the underlying causes of poverty and disadvantage with emphasis on working in partnership with stakeholders. It highlighted that "rights-based projects show a greater range and depth of positive impacts, and these are more likely to be sustained over time" Crawford (2007: 9) and participation under RBAs was linked to fulfillment of obligations and inclusion. RBAs, according to Crawford (2007), were successful in inspiring people's political agency; encourage greater

autonomy and ownership of development processes; increase the odds of achieving unrelenting positive change; can succeed in removing underlying causes of poverty by engaging with power inequity; and increase the chances that people will be able to withstand shocks.

Donald (2012) identified core broad principles of RBA generally regarded as PANEL principles which is derived from the five principles namely participation, accountability, non-discrimination, empowerment and legality. The study highlighted the importance of making a smooth-tongued distinction between rights as a set of legal and normative standards, and human rights as a source of methods and principles for the realization of those standards. There is no set template for mainstreaming human rights thinking and practice into an organization suggesting that the process involves inventiveness rather than use of prescription. The study established that the requirements for successful RBAs are: leadership guidance and support in the process; participation of both right holders and duty bearers; creation of RBA champions; behavioural change which entails self-reflection and helps shape organisational culture; training; integration of human rights into existing practices; regular review of policies and procedures; making use of human rights expertise external to the organisation; raising awareness on rights; public commitment to rights by all stakeholders; and a focus on the rights of all those that are affected.

METHODOLOGY

The study was a descriptive survey that was underpropped by a pragmatism research philosophy that employed a mixed methods approach with a largely qualitative concurrent embedded strategy. This strategy entailed the concurrent use of both qualitative and quantitative data collection tools in the collection and analysis of the data corpus. The study was undertaken in Mutoko District (Zimbabwe) focussing on the period 2001-2011. Data were collected through interviews, observations and focus group discussions with a total 98 participants from 25 villages and 9 organisations being directly studied. Participants were selected using probability and non-probability sampling methods. Data were analysed using the thematic approach and SPSS. The study was anchored on the understanding of poverty as an outcome of structural inequalities consistent with human rights violations. This approach produced results that are largely qualitative and an inevitably drawing of equally qualitative conclusions and recommendations.

RESULTS AND DISCUSSION

The study results are presented and discussed under the following thematic areas:

Understanding Poverty and its Dynamics

Participants and discussants generally defined poverty from the income and basic needs perspectives and this includes some of the Key Informants including those from rights-based organisations. There was little reference to violation of rights and results did not significantly vary when clustered around other variables such as sex (gender), age, level of education or geographical area. These results are in keeping with findings by Rumbewas (2009) which noted that the material definition of poverty is still dominant and other observations that satisfaction of elements of deprivation are given priority in cases of extreme poverty. This is contrary to findings by Nyasulu (2009).

Poverty was attribute to individual deficiencies and to a lesser extent limited opportunities and much lesser extent inequalities. This tallies with the material definition of poverty but contrary to many submissions and findings (Boesen and Martin, 2007; Kindornay et al., 2012) that inequality is the underlying cause of poverty. Consistent with many other studies in Zimbabwe (Chiripanhura, 2010; Kinsey, 2010; Mpofu, 2011; Chigumira and Chizema, 2011; Kanyenze, 2011, ZIMSTAT, 2013), poverty increased during the period 2001-2011. While these studies measured poverty in money-metric terms just like the participants, even when measured in non-income terms including human rights indicators, any reduction in poverty levels must result in changes in money-metric poverty levels in keeping with the dimensional monotonicity axiom (Alkire and Santos, 2010).

Understanding Rights-based Approaches (RBAs)

Most participants did not know the differences between RBAs and needs based approaches. Those that claimed to know, including development workers, could not articulate the differences. Orientation on RBAs was weak and rushed. Some issues noted as essential requirements for successful rights-based development are elements of needs based approaches. These results are consistent with other findings notably by Kindornay et al. (2012) that understanding of RBAs is weak in many organisations and communities.

Quantity and Quality of Development Outputs and Outcomes

Subsequent to the deployment of RBAs, the study showed that the quantity of development outputs and outcomes had not increased while the quality improved possibly due to focussed attention on project management with unchanged quantity. The distribution of outputs did not improve which suggests unequal power relationships remained unbothered which is consistent with findings by Bruno-van Vijfeijken et al. (2010).

Development Strategies Deployed

Responses show that substantive participation was not used in development processes, and priority given to both empowerment and participation did not increase. Participation levels actually decreased after introduction of RBAs. In tandem with this, largely top-down approaches were used and processes were not locally owned but driven by outsiders. It also showed that capacity building and empowerment strategies were used to create demand for projects. Development efforts focussed mainly on lobbying and advocacy. Strategies were effective in containing poverty levels after they had reached unprecedented levels, a reduction which is rather transitory but not effective in sustainably reducing poverty levels. Rights-based strategies are appropriate in our context and this was based on their design not how they were used. NGOs have meaningfully contributed to poverty reduction and development in rural areas but have not been close to the poor given the results on substantive participation. Strategies used had not improved relationships between communities and development agencies and there is not much to point to the presence of RBAs increased lobbying, advocacy and reference to human rights in development programs. These results resonate with findings by Kindornay et al (2012) and Bruno-van Vijfeijken et al. (2010), among others with regards mainly to issues of participation, ownership of development processes, a focus on lobbying and advocacy, and use of rights as a tool for analysis rather than a basis for action. This is also linked to weak understanding of RBAs in theory and practice.

Results of Rights-based Approaches

The study showed that RBAs did not lead to empowerment of families and communities and participation as well as duty-bearer accountability to rights-holders did not increase. Some of the proponents of RBAs who are moral duty bearers were cited as being unaccountable to communities. Similarly, local leadership accountability had not increased. These are central elements of RBAs that serve as indicators for progress towards RBA development as outlined in the Statement of Common Understanding on Rights-based Approaches (UNICEF, 2003) and the PANEL principles (Donald, 2012). This highlights the fact that RBAs were not effective in addressing underlying causes of poverty which is heavily linked to the limited understanding of RBAs and implementation tools as observed by Kindornay et al. (2012).

Performance of Development Players

The study revealed that NGOs carried their duties effectively during the period but lacked coordination and collaboration. Government departments and families blamed them for the low progress recorded in poverty reduction and development. Limited understanding of the RBAs could have caused this as NGOs maintained their dominance which was also highlighted by the study by Bruno-van Vijfeijken et al. (2010).

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Human Rights and Development

Introducing human rights to the communities and other local development players was not an easy task since it is technically challenging for fair articulation and resistance to some human rights issues can also be attributed to this. Communities are generally comfortable with human rights and rights-based approaches as an important component of poverty reduction and development processes and programs and noted that human rights are compatible with endogenous discourses. The points outlined by discussants and informants as crucial for successful poverty reduction and development are some of the key variables for successful RBAs. These include transparency, accountability, participation, empowerment and clarity on roles and this is consistent with the Voices of the Poor study which noted the need to change social norms (Narayan et al., 2000b) and many other studies reviewed.

Overall, the results echo the argument that poverty is not the fault of an individual, an argument also sustained under RBAs. This argument is found in the submissions by the community participants and discussants on their expectations from development processes and players.

CONCLUSIONS AND RECOMMENDATIONS

Development stakeholders do not fully acknowledge the multi-dimensional nature and character of poverty as well as its multiple causes that are deeply sited within power relationships. There is weak understanding of RBAs and this largely arose from weak orientation. Implementation of RBAs was weak and in some cases adulterated models were deployed as highlighted by implementation of some RBA strategies leaving out the others. Implemented strategies, falling within the ambit of RBAs, are appropriate but have not been effective and hence have not made a significant impact on poverty reduction and development. The study concluded that equal power relations, agency (including capabilities) of marginalized groups as well as their participation and inclusion, shared goals, transparency and accountability, and clarity on roles and responsibilities are some of the important variables of Rights-based Approaches. These have nonetheless been conflictingly applied worse still within adulterated rights-based models as programs merely addressing rights and not necessarily RBAs.

The RBAs have had no significant practical impact on poverty reduction and development not necessarily because of their design structure but mainly due their weak and hasty implementation. Development, endogenous discourses and human rights are compatible and mutually reinforcing, and their synergistic potency needs to be harnessed to confront poverty and inequality. The NGOs have not fully transformed themselves to operate as equal partners with other players in keeping with the dictates of RBAs and resultantly are still largely prescriptive in their approach not accountable to the poor. The study concludes that the government has not been at the centre of the development enterprise as constitutional duty bearers.

In summary, with reference to the broad research question, the study concluded that RBAs are appropriate but were not effective in reducing poverty largely due to their weak understanding and implementation. However, in normal practice the view that RBAS are not effective in reducing poverty may be revisited given that their key variables resonate well with issues raised as necessary for the realization of poverty reduction and development by the study. An assessment based on outcomes showed RBA strategies were effective in stabilizing poverty levels against the odds of an adverse macro-economic environment but had not influenced development processes. If adequately and appropriately implemented RBAs can be effective. However, in the absence of evidence especially of transformation of power relations. RBAs will continue to be associated with more rhetoric than reality.

In view of the above findings, the researchers make the following recommendations

1. Clear and measurable/verifiable process and outcome indicators to measure rights-based development and poverty reduction must be developed.

2. Adequate and appropriate orientation on RBAs must be delivered to all stakeholders in order to secure adequate buy-in, and mutual focus and deployment of resources towards poverty reduction and development. Inevitably this also means creating and nurturing RBA champions to expedite full embracement of RBAs. Better understanding of RBAs is key to the transformation of development institutions and structures.

3. RBA strategies must be appropriately and consistently implemented if they are to be effective and this entails consistent patience since processes that are meaningfully participative in nature are naturally slow and seldom produce instant outcomes since they begin with process enrichment.

4. Confronting unequal power relations in order to build the agency of the marginalized individuals and their collectivities must be the driving power behind any RBA model.

5. Pure and unadulterated RBAs must be slowly but consistently implemented in order to avoid generating confusion amongst stakeholders and discredit RBAs.

6. Development must harness the mutually reinforcing values within rights and endogenous discourses. This is key in transforming relationships and institutions.

7. The NGOs need to transform themselves into 'corporations of the poor' by opening up space for the poor in order to play a meaningful role to address their plight and in the process eliminate patron-client relationship between them and the poor.

8. The state and governance must be the dominant features of responsibility and all development processes including overseeing the development players. The NGOs are merely helping the state to deliver its development duty.

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SEED GERMINATION AND SEEDLING GROWTH OF TOMATO (LYCOPERSICON ESCULENTUM) ON VARIOUS MEDIA IN A HOTBED SYSTEM

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ABSTRACT

The Seedling establishment is largely affected by both biotic and abiotic factors amongst them is the type of growing media used. A suitable growing media should have the capacity to hold sufficient moisture, nutrients, allow efficient gaseous exchange, root growth and physically anchor the seedlings. Temperature which is also a critical abiotic factor can be enhanced through the use of hotbeds. The specific objective of the study was to assess germination and early growth response of tomato (Lycopersicon esculentum) seedlings to various growing media when sown in hotbeds. This would enable the identification of the most suitable sowing media under the hot bed technology. Four different growing media were used namely; coco peat, composted pine bark, composted farmyard manure and naturally composted manure. The four treatments were administered using polystyrene seedling trays as experimental units in a completely randomized block design with three blocks. F-tests were carried out to analyse data collected on the percentage germination, numbers of days to 50% germination and seedling stem height. The coco peat growing media showed superior performance in all parameters that were tested while the composted pine bark which is usually used as the standard growth media showed the least performance. This can be attributed to good air to water ratio of the coco peat based media. Use of coco peat can be recommended though it is noteworthy that it is expensive and may not be readily available to resource poor nurserymen.

***Key Words**: Lycopersicon esculentum, coco peat, pine bark, composted manure, polystyrene trays uman Rights, Poverty, Inequality*

INTRODUCTION

Growing media are materials that physically support plants grown in them. They hold water, may provide nutrients and a suitable environment for germination, growth and development of seedlings. However, variations are existent in physical and chemical properties of different growing media. The physical and chemical composition of a growing media determines rate of germination, seedling quality, survival and performance after transplantation (Fagge & Manga, 2011). Several features of a suitable growing media have been widely researched on and documented, these include but are not limited to; aeration, porosity, carbon: nitrogen content, pH, wettability, and adsorption of minerals, cation exchange capacity (CEC), and the ability to suppress fungal infections (Lazcano *et al*., 2009; Michel, 2010; Aklibasinda *et al*., 2011; Boodia *et al*., 2011& Goss *et al*., 2013).

The commonly used growing media in horticultural nurseries are peat, compost, soil and bark based. Loamy or sand soil is the cheapest and most available soil based growing media for resource poor seedling dealers. Concerns on its quality and land degradation issues have seen a paradigm shift to soilless growing media in the production of horticultural crops (Awang *et al*., 2009; Boodia *et al*., 2011). Soilless growing media like coconut coir also known as cocopeat, peat moss and pine bark have gained popularity. Peat is partially decayed organic materials obtained from wetland ecosystems and the commonly used peat based growing media is the Sphagnum peat moss (Lopez, 2008). Peat based growing media have been found to suppress pathogenic fungi, however high costs of extraction, unavailability and environmental concerns have resulted in increased research and use of alternatives (Landis & Morgan, 2009). Composted pine bark is used as a standardized media for horticultural nurseries. It was found to be of low cost, high water

retention capacity, balanced air and water content. It has also been proven to suppress root-rot fungi (Castillo, 2004 & Handreck, 2005).

Coconut coir is a growing media made from the extracts of fiber from coconut shells (Abad *et al*., 2002). It is widely produced in coastal regions and exported to other parts of the world. The fiber material is ground, washed, screened and composted. It is used as a substitute to peat moss because of its high lignin content, slow decomposition rate, easy wettability, high water retention capacity and an ideal pH (Abad *et al*., 2002; Landis & Morgan, 2009). However, it can be of high CEC if the husks are stored in salty water hence it needs leaching with fresh water before use (Landis & Morgan, 2009). Compost based media show greater variations in chemical and physical properties depending on the waste materials used (Chong & Purvis, 2006). Usually animal manure, green plant materials, decaying plant leaves and roots or household waste material are used separately or in combination. Compost based growing media are rich in fertility, good porosity and aeration (Chong, 2003). However, they are prone to fungal infections and are suitable for the growth of native plants (Wilson & Stoffella, 2006). Resource poor nursery men use the compost based growing media collected under growing trees or shrubs in natural ecosystems. In some parts of Zimbabwe, it is locally known as "*Iwakwane*".

Seedling production is a viable enterprise especially for high value crops like tomatoes; however, nursery men fail to raise seedlings in large numbers due to limited arable land, poor germination, time taken to germination and poor survival of seedlings (Lazcano *et al*., 2009). Seedlings are usually needed in large numbers during planting time hence hotbeds are used to hasten the process of seed germination in order to economize on space and time. Tomato is a frost susceptible fruit hence seedlings cannot be raised in winter without special growing structures like hotbeds and green houses. However, if the seedlings are raised successfully in winter and planted early in summer the crop fetches high pre-market prices which benefits the farmer.

Hotbeds are a modern technology used to manipulate the seedbed temperatures in order to hasten germination and growth of seedlings. Hotbeds are differentiated through the mode used for heating growing media where seeds are sown thus electrically heated, warm air (flue heated), manure heated and Steam or hot-water heated hotbeds are used. The effects of hotbeds on different growing media and its impact on early growth and development of seedlings has not been widely documented. Increased temperatures tend to alter some physical and chemical properties of any solid material as such properties of growing media and growth of seedlings are likely to be affected. Increased oxygen demand due to increased respiration in plant roots and microbial activities is duly expected ultimately affecting seedlings growth. Good emergence and stand establishment of seedlings ensures better yield in vegetable production (Sudhakar *et al*., 2008). The findings of the study will therefore help seedling producers to choose the most appropriate media when using hotbeds. It will also stir up further research on the influence of hotbeds on chemical and physical properties of different growing media. The study was intended to investigate the effects of different growing media on seed germination and early growth of tomato seedlings sown in the hotbeds.

MATERIALS AND METHODS

Experimental design

Experiments were set up in a Randomized Complete Block Design (RCBD). Growing media as the factor under investigation had four treatment levels namely; Coco peat, composted pine bark (CPB), composted farmyard manure (CFM) and naturally composted manure (NCM). The control treatment was the naturally composted manure made of leaf litter collected under naturally growing trees mostly the *Acacia tortilis* species. Treatments were randomly allocated in three blocks. Polystyrene seedling trays with 200 cells were used as the experimental units and were stacked randomly one on top of the other to form a block in the hotbeds. The same design was maintained when the germinated seedlings were taken to the shade house where the polystyrene seedling trays were unstacked and laid side by side in three blocks on raised benches that ran in a North-South direction thus blocking according to the direction of the movement of the sun.

Sowing and management

Each tray was filled with different growing media following the design of the experiment. One tomato seed was sown in each cell of the tray at a depth of 1 cm and covered by the growing media. Trays were placed in hotbeds for a maximum of 72 hours. The hotbeds were heated using heaters at temperatures between 26°C and 30°C. The seedlings were then transferred to a shade house after 72 hours to avoid denaturing of the seedlings that had already emerged and kept for 4- 6 weeks during which seedling emergence and the early growth were assessed. In the shade house the seedlings were placed on benches 1 meter above ground. Watering was done using micro-jets for 1 hour three times daily. The Rodade variety obtained from Bulawayo Seeds Company, was used. The choice of the variety was based on availability. The chemical composition of the growing media used were analyzed in the laboratory before sowing, (Table 1).

Table 1. **Chemical composition of four growing media used in the study analyzed before planting.**

Chemical element tested	NCM	CPB	Coco peat	CFM
Nitrogen (%)	0.89	0.23	0.42	0.90
Phosphorus (%)	0.12	0.14	0.12	0.16
Calcium (%)	0.1	0.28	0.09	0.16
Potassium (%)	0.18	0.14	0.66	0.23
Magnesium (%)	0.15	1.20	0.25	0.19
Iron (ppm)	4050	5688	3075	4538
Manganese (ppm)	308	385	38	280
Zinc (ppm)	38	45	51	74
Boron (ppm)	16	22	27	20
Copper (ppm)	9	27	11	10

NCM –Naturally composted manure, CPB- Composted Pine bark, CFM- Composted farmyard manure.

Data collection

Data on days to 50% germination, number of seedlings germinated after a week were recorded per treatment and the percentage germination computed. Furthermore, seedling stem height (from the collar leaves to the tip of the youngest leaf) was measured using a ruler every week for 6 weeks after germination to determine seedling vigor.

Data handling and analysis

All the data collected were subjected to Analysis of Variance (ANOVA) to detect any significant differences between treatments at 5% significance level. The data on number of days to 50% germination, number of seedlings germinated after a week was transformed using the square root transformation to attain normality before being subjected to ANOVA. Where significant differences were detected the means were separated using the least square differences (LSD) at 5% significance level.

RESULTS AND DISCUSSIONS

Effects of growing planting media on seedling germination

The Analysis of variance results revealed that the type of growing media had a significant influence on mean percentage germination and number of days to germination of tomato seed that was sown in four different growing media. A significantly higher percentage germination of 70% was observed in seedlings sown in coco peat based growing media whereas the composted pine bark media showed the least germination percentage of 34.1% (Table 2). A similar trend was observed in the mean number of days to 50% germination. More than 50% of the seed sown in coco peat had germinated within 3 days after sowing, while in composted pine bark media it took an average of 5 days for at least 50% germinated seedlings to be observed. No significant differences were observed in the number of days taken by seeds sown in composted farmyard manure and naturally composted manure (Table 2).

Table 2. Effects of different growing media on germination of tomato seed

Growing media type	Mean percentage germination	Mean number of days to 50%
Coco peat	70.75 [a]	3 **a**
Composted Pine bark (CPB)	34.08[d]	5 [c]
Composted Farmyard manure	61.83 [b]	4 **b**
Naturally composted manure	54.25 [c]	4 [b]
F-test prob.	< 0.001	< 0.001
LSD 0.05	0.86	0.13
CV %	4.5	2.5

Treatments indicated using different superscripted letters were significantly different at F pr 0.05. The superior germination performance observed on the seed sown in coco peat based media shows that coco peat based media provided ideal conditions for germination under hot beds. This can be attributed to its high lignin content which

decomposes slowly hence rendering the media high wettability, good aeration and water holding capacity to enhance germination (Landis & Morgan, 2009). Increased water holding capacity of the media also means a stable heat retention of the media in hotbed due to the inherently high heating capacity, fusion and vaporization properties of water. The composted farmyard manure and naturally composted manure based media are readily available and widely preferred by resource poor seedling dealers but retard germination when compared to the coco peat based media. According to Lopez et al., (2008), water holding capacity tends to be lower in compost based growing media which then delay germination.

Influence of different planting media on seedling stem elongation

Early growth of seedlings in terms of stem height was significantly influenced by the type of growing media. Significantly higher mean plant height values ($P< 0.001$) for seedlings sown in coco peat based media and significantly lower values for seedlings sown in composted pine bark media were observed throughout over 5 weeks after germination (WAG). On week 6 the coco peat based media showed no significant differences from the composted farmyard manure in influencing seedlings growth in terms of height. Analysis of variance results showed no significant differences in seedlings height between the composted farmyard manure and the naturally composted manure based media treatments over a period of 6 WAG. At 6 WAG, seedlings grown in composted pine bark had the lowest mean stem height of 28.5mm compared to 50.2 mm, 49.6 and 47.4 respectively for coco peat, composted farmyard manure and naturally composted manure.

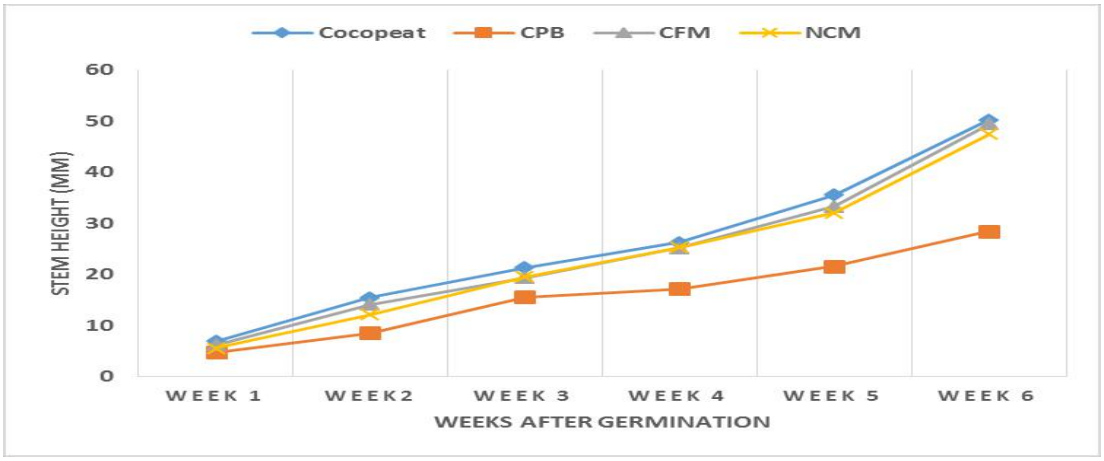

Figure 1. Curves of stem height for tomato seedlings sown and grown in four different growing media used in the study and observed over 6 weeks.

The good growth performance of seedlings sown in coco peat media can be associated with optimum conditions for air-water ratio in solid and porous materials like coco peat which favours gaseous exchange in the root zone (Landis & Morgan, 2009), though it is often argued that high water holding capacity may compromise the air-water relationship (Awang et al., 2009). The high levels of potassium in coco peat based media that were observed (Table 1) can also be linked to increased vegetative growth in seedlings as it was noted by El Nemr (2012), Lin & Danfeng in (2003). Marschner, (2002) postulated that potassium is one of the most absorbed nutrients by tomatoes during root and leaf establishment which in turn favours vegetative growth. However, excessive salts from coconut residues can be a problem with germinating and young plants sown in coco peat if not thoroughly soaked and leached off before use (Carrion et al., 2006; Boodia et al., 2011).

CONCLUSIONS AND RECOMMENDATIONS

Amongst the four growing media that were assessed in the study, coco peat based growing media appeared to promote good and fast seedling emergence and growth. Use of coco peat can be recommended to improve efficiency in

seedling production, however, it is noteworthy that it is relatively expensive and scarce in some parts of the world away from the coastal areas. Further research may focus on effects of hot be technology on the physical and chemical properties of various growing media.

ACKNOWLEDGEMENTS

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A COMPARATIVE ASSESSMENT OF ANTIOXIDANT RESPONSES OF CHROMOLAENA ODORATA DURING EXPOSURE TO HEAVY METAL POLLUTION

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ABSTRACT

The antioxidant responses of Chromolaena odorata to heavy metal pollution were investigated. Stems of Codorata were planted in soils polluted with Pb, Mn, Zn, Cd, and Cu at the ecological screening concentration of 50 mg/kg (Pb, Mn and Zn), 4 mg/kg (Cd) and 100mg/kg (Cu) of metal per kilogram of soil, in varying concentrations of 0 ESV (control), 1 ESV, 3 ESV and 5 ESV. After the exposure of C. odorata to heavy metals for 3 months, results showed significant heavy metal accumulations in plant leaves. There were more root accumulations of the metals than by both stem and plant leaves. Plants accumulated more of Mn than any other metal (8.09 – 10.21 mg/kg). Accumulation of hydrogen peroxide in plant leaves metal-exposed plants was higher than in the control. H2O2 was significantly lowest in Pb-exposed leaves, followed by Zn-exposed leaves. Lycopene levels in HM-exposed plant leaves ranged from 131.04 – 249.60 U/mg, compared to 67.86 U/mg in the control. Comparatively, SOD concentrations in plant leaves were more than 5 times higher than CAT levels in plant leaves. Similarly, ascorbate levels in plant leaves increased by HM incident.

***Key Words**: Heavy metals, antioxidants, Chromolaena odorata, stress, ecophysiology*

INTRODUCTION

Soil contamination with heavy metals has been one of the most important factors resulting in poor plant growth and development. Apart from the effects on morphology, heavy metal contamination results in a myriad of biochemical, physiological and anatomical anomalies, culminating in overall poor plant growth. Heavy metals have the capability to induce the formation of free radicals or Reactive oxygen species (ROS), leading to cellular oxidative stress. Enzyme activity is also hindered by heavy metal accumulation (Henry, 2000). However, the capacity of plants to tolerate heavy metal contamination relies basically on a network of enzymatic and non-enzymatic antioxidant responses. Plants can tolerate the consequences of elevated heavy metal concentrations through enhancing its antioxidant defence capacities. This is necessary to forestall the damaging impacts of reactive oxygen species, which accumulate in plant cells in response to metal accumulation (Kachout et al., 2009; Solanki and Dhankhar 2011). As oxidizing agents, reactive oxygen species cause oxidative impairment to biomolecules which will invariably result in the death of the cell (Gunes et al., 2006). Kachout et al. (2009) earlier reported that there is a strong correlation between plant tolerance to heavy metals and a concomitant rise in antioxidant status. The activities of protective enzymes like catalase (CAT), superoxide dismutase (SOD), glutathione peroxidase (GPX), and ascorbate oxidase (AO), help to keep the levels of radicals low and in most cases, harmless. SOD as a metalloenzyme catalyzes the breakdown of superoxide molecules into hydrogen peroxide and oxygen; CAT, on the other hand, speeds up the detoxification of hydrogen peroxide into water and oxygen (Beyer et al., 2008). The capacity of a plant to subsist in a metal tolerant soil suggests increased remediate capacity of the plant or, perhaps tolerance capacities. Knowing fully well that direct exposure to these metals would result in oxidative damage, and also may lead to impaired cellularionic homeostasis (Yadav,2010), it is therefore suggested that such a plant may have enhanced antioxidant capacities. Increased production of free radicals on exposure of microorganisms to drought and salt stress has also been reported (Price and Hendry, 1991). Increased SOD activity has been reported in Scenedesmus binugatus exposed to different concentrations of copper (Dietz et al., 1999).

One of the activities of reactive oxygen species (ROS) in cells is the destruction of the lipid membrane of the cell. This is usually indicated, in many cases, by the presence of malondialdehyde (MDA).

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MDA is one of several indicators of ROS generation; it is a cytotoxic product of lipid-peroxidation caused due to increased lipoxygenase activity (Elia et al., 2003). An increased production of MDA was reported in Spirulina platensis-S5 a blue- green alga, under heavy metal stress condition (Agrawal, 1992). High MDA level has also been observed in various higher plants (Chaoui et al., 1997).

A number of plant species have been reported to play significant roles in the cleanup of heavy-metal enhanced soils. One of such plant species is Chromolaena odorata . Coping mechanisms established by this plant facilitate the formation of supportable ecosystems inregions that would otherwise remain barren. Chromolaena odorata (L) King and Robinson (Family Asteraceae) is one of the world's worst tropical weeds, though native to South and Central America. It has an enormously fast growth rate (up to 20mm per day) and abundant seed production, and at least a life span of approximately 10 years. Some studies have shown its ability to exist in oil- and HM-polluted environment (Anoliefo et al.,2006, 2008; Agunbiade and Fawale, 2009; Ikuenobe and Anoliefo, 2003; Uyi et al., 2014; Ikhajiagbe, 2016).

MATERIALS AND METHODS

Plant Materials and soil samples

Measured quantities (25kg) of top-layered garden soil

(0– 10 cm) were collected and polluted with heavy metals (Pb, Mn, Zn, Cd, and Cu) by a factor of the respective ecological screening benchmarks (ESV) of 50 mg/kg (for Pb, Mn and Zn), 4 mg/kg for Cd, and 100mg/kg for Cu. The metal concentrations were varied as 0 ESV (control), 1 ESV, 3 ESV and 5 ESV. The set up was allowed to naturally attenuate for 24 hours before equal sized stem cuttings of C. odorata (2.0 - 2.3cm in thickness) and length (30cm) were planted vertically into the soil with 10 cm of stem cutting buried into the soil. Two stem cutting was planted per bucket. The set up was kept in a screen house for 3 months. Care was taken to ensure that the soil moisture was always optimal (USDA, 2000).

Physicochemical parameters

After 6 months, roots, stems and leaves of exposed plants were taken to the laboratory to analyze for metal accumulations. Soil physicochemical parameters were also analyzed, though, this was prior to soil contamination with the respective heavy metals (Bray and Kurtz, 1945a, b; SSSA, 1971; Nasir et al., 2015).

Sample preparation for enzymatic antioxidant activity

Approximately 500 mg of plant samples were homogenized in cold extraction buffer (50 mM potassium phosphate pH 7.0, 1% (w/v) polivinylpyrolidone) using mortar and pestle. The homogenates were subjected to centrifugation at 15,000 x g for 10 minutes at 4ºC and the supernatant were kept as enzyme extract.

Determination of the antioxidant enzymes' activities

Superoxide dismutase (SOD; E.C. 1.15.1.1) activity was assayed by measuring its ability to inhibit the photochemical reduction of nitrobluetetrazolium (NBT) and the change in absorbance was measured at 560 nm (Beauchamp and Fridovich, 1971). The reaction mixture consisted of 25 mM phosphate buffer (pH 7.8), 65 µM NBT, 2 µM riboflavin, enzyme extract, and TEMED and the reaction mixture was exposed to light of 350 µmol m−2 s−1 for 15 min. Catalase (CAT; EC 1.11.1.6) activity was determined following the methods of Aeby (1984). Ascorbate peroxidase (APX; EC 1.11.1.11) was determined according to the method. described by Nakano and Asada (1981). The reaction mixture consisted of phosphate buffer, 5 mM sodium ascorbate, 0.1 mM of H2O2 and supernatant. Total ascorbate peroxidase activity was determined as the decrease in absorbance of ascorbate at 290 nm and calculated using a molar extension coefficient ε = 2.8 mM−1 cm−1. The enzyme activity was calculated as the amount of the enzyme that oxidizes 1 nmol of ascorbate consumed per mg of soluble protein per min at 30°C. The acid–ninhydrin method was used to determine the proline content. The plant material (0.5 g) was homogenized in 10 mL of sulfosalicylic acid (3 g per 100 mL) and the homogenate was filtered through Whatman No. 2 filter paper. The reaction mixture containing 2 mL of homogenate, 2 mL of acid ninhydrin and 2 mL of glacial acetic acid was incubated at 100 °C for 1 h. The reaction mixture was placed on ice and extracted with 4 mL of toluene. The absorbance was read at 520 nm using toluene as the blank. The proline content expressed in micromoles proline per gram fresh weight was calculated as described by Bates et al., (1973). Malondialdehyde was determined using the thiobarbituric acid assay (Buege and Aust, 1978).

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EXPERIMENTAL DESIGN

The experimental design adopted for this study was the completely randomized design, following the assumption of homogeneity of the entire experimental plot. This was so because the soil used in the experiment was collected and pooled together to get a composite sample before redistribution into separated experimental bowls. Also the plant stem cuttings were randomly corrected and pooled before utilization.

RESULTS AND DISCUSSION

The soil was reportedly ferruginous, with increased Fe content (1011.92 mg/kg) (Table 1). Cadmium was below detection. However, 3 months after soils were heavy-metal polluted, significant accumulations were reported in plant parts (Table 2). There were more root accumulations of the metals than by both stem and plant leaves. Accumulation of Mn was within the ranges 8.09 – 10.21 mg/kg, whereas plant accumulation of copper was within the value ranges 3.43 – 4.32 mg/kg.

Mean H2O2 conc. in leaves of Mn and Cd-exposed plants were higher than the control (Fig. 1). H2O2 was significantly lowest in Pb- exposed leaves, followed by Zn-exposed leaves. Hydrogen peroxide concentration in Mn, Cd, Zn and Cu-exposed plant leaves (0.66 – 1.08 mM/g) did not differ significantly from the control (0.68 mM/g). However, plant exposure to Pb resulted in significantly levels of hydrogen peroxide quantified in the plant leaves (0.18 – 0.41 mM/g). Carotenoid levels of HM-exposed and control plant leaves have been presented in Fig. 2. There was significant increase in carotenoid levels with incident of HM pollution ($p<0.05$). These increases were particular to Mn+5ESV (1708.1 U/mg), Pb+5ESV (1744.1 U/mg), Cu+1ESV (1718.2 U/mg), and Cu+3ESV-polluted plant leaves (1850.6 U/mg). Similarly, carotenoid levels were all enhanced by Zn soil contamination (1746.3 – 2218.2 U/mg). Significant increases in lycopene contents of leaves were reported due to HM contamination

(Fig. 3). Lycopene levels in HM-exposed plant leaves ranged from 131.04 – 249.60 U/mg, compared to 67.86 U/mg in the control. Apart from plants in Mn-polluted soils, plants exposed to Cd, Cu, Pb and Zn have generally showed higher lycopene levels in 1ESV HM concentration, but lycopene levels significantly dropped at 5ESV. However, in spite of this drop, overall lycopene levels in all HM-exposed plants were still higher than control levels. However, tocopherol levels in HM-affected plant leaves did not significantly differ from the control ($p>0.05$). Generally, tocopherol levels ranged from 1.42 – 2.80 µg (Fig. 4).

Fig. 4 shows superoxide dismutase (SOD) and catalase (CAT) activity of leaves of developed Chromolaena odorata at 3 months after sowing. No significant differences in SOD levels as well as CAT levels of both metal-exposed and control plant leaves were reported ($p>0.05$). Generally, SOD levels in HM-exposed and control leaves ranged from 177.31 – 179.89 mol/g tissue, whereas CAT levels ranged from 21.39 – 29.06 mol/g tissue. Comparatively, SOD concentrations in plant leaves were more than 5 times higher than CAT levels in plant leaves.

Malondealdehyde (MDA) concentrations in plant leaves are used to estimate the level of lipid peroxidation that is due to oxidative stress. Any significant increase in MDA in HM-exposed plants when compared to the control would ordinarily imply that such measured lipid peroxidation is due entirely, or in part, to HM incident. However, in the present study, there were no differences between MDA levels quantified in the HM-exposed plant leaves (3.6 – 5.3 x 10-6mol/g tissue) and those of the control plants (4.45 x 10-6mol/g tissue) (Fig. 5). Significant increases were observed in Cu-stressed leaves (0.71 – 1.11 mM/g), compared to the control (0.095 mM/g) (Fig. 6). However, minimal differences ($p>0.05$) were reported in proline concentrations of Mn, Cd, Pb, and Mn-exposed plant leaves as compared with the control.

The ascorbate levels in plant leaves were increased by HM incident (Fig. 7). Whereas ascorbate concentration in the control leaves were 2.55µg/g, levels were as high as 6.51µg/g in Zn+5ESV and 6.58µg/g in Mn+5ESV respectively. Lycopene fairly correlated with carotenoids ($r = 0.419$, $p<0.05$) (Table 3). Pearsons coefficient of correlation for other paired antioxidant parameters were not significant both at 1-tailed and 2-tailed.

In the bid to ascertain contributions of selected plant antioxidant parameters towards the determination of the influence of the latter on plant antioxidant defense against HM toxicity, the different antioxidant measured in the study were pooled together in a principal component analysis (PCA). Results showed that carotenoids as a parameter, loaded highly significantly as a component matrix (Fig. 2), an indication that this

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was the most important component in assessing plant antioxidant defense response to HM toxicity. However, with a KMO value of 0.32, thus indicating a fairly adequate sampling, and with the Bartlett's Test of Sphericity indicating a no-significance ($p>0.05$), this reliance on carotenoid as being the most prominent antioxidant does not necessarily suffice. Hence, none of the parameters considered had prominent influence on plant's antioxidant response.

Table 1: Physico-chemical properties of soil before contamination. These are background mean concentrations (n = 5). (mean±S.E.M)

Parameters	**Mean value (n = 5)**
pH	5.97 ± 0.67
Electric conductivity (µs/cm)	301.21 ± 23.01
Total organic carbon (%)	0.49 ± 0.09
Total Nitrogen (%)	4.18± 1.06
Exchangeable acidity (meq/100g)	0.22 ± 0.08
Na (meq/100g)	10.90 ± 2.11
K (meq/100g)	1.48 ± 0.62
Ca (meq/100g)	14.32 ± 3.10
Mg (meq/100g)	12.01 ± 3.22
Heavy metals	
Fe (mg/kg)	1011.92 ± 73.38
Cd (mg/kg)	<0.001
Mn (mg/kg)	17.03 ±3.22
Pb (mg/kg)	0.03 ± 0.01
Cu (mg/kg)	3.93 ± 0.01
Zn (mg/kg)	30.12 ± 3.06

Table 2: Heavy metal concentrations (mean±SD) in plant leaves after 3 months.

HM	Total heavy metal concentrations in leaf(mg/kg)				
	Mn	Pb	Cu	Cd	Zn
Control	2.46±0.54	<0.001	<0.001	<0.001	8.24±3.73
1ESV	10.21±2.36	1.45±0.15	3.43±0.37	0.68±0.21	2.04±0.31
3ESV	8.23±0.47	1.51±0.98	4.21±0.19	101±0.29	2.01±0.06
5ESV	8.09±1.75	2.01±0.51	4.32±1.15	0.92±0.19	1.87±0.11
p-value	0.628	0.789	0.564	0.513	0.75
LSD(0.05)	4.97	5.48	3.66	0.93	1.93

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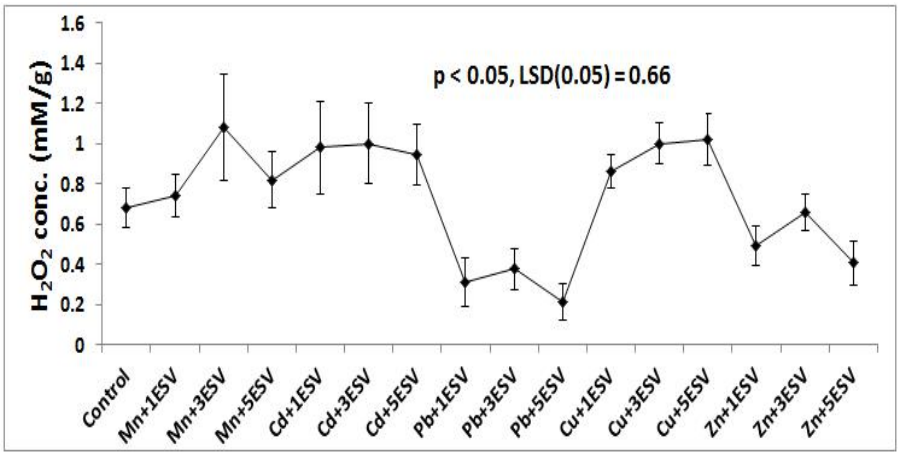


Fig 1: Estimation of foliar accumulation of hydrogen peroxide upon exposure of *Chromolaena odorata* to metal contamination at 3 months after sowing

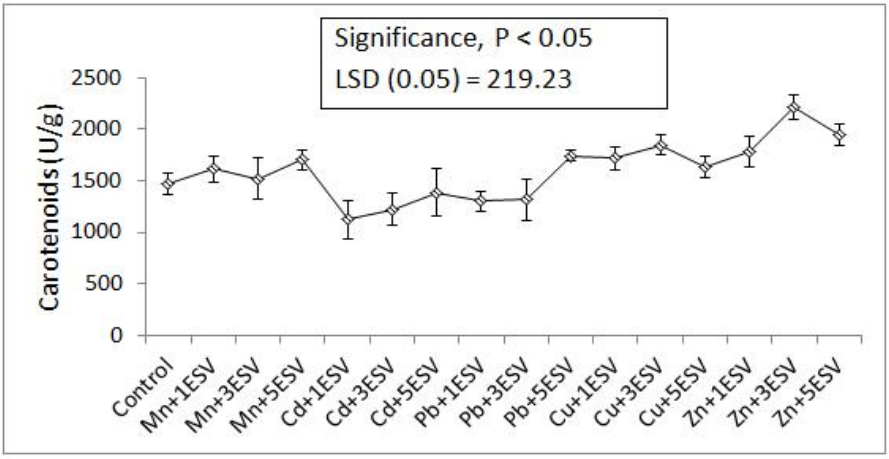


Fig. 2: Carotenoid activity of leaves of developed *Chromolaena odorata* at 3 months after sowing

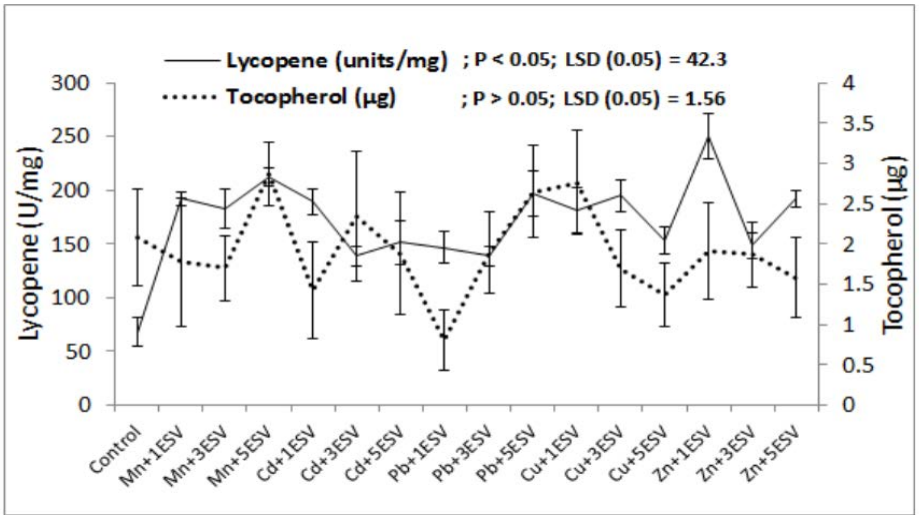


Fig.3: Lycopene and tocopherol activity of leaves of developed *Chromolaena odorata* at 3 months after sowing

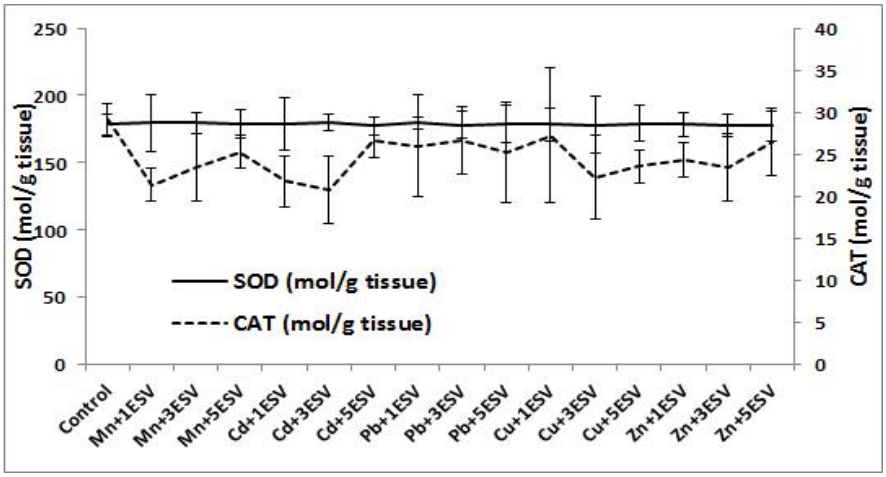


Fig. 4: SOD and CAT activity of leaves of developed *Chromolaena odorata* at 3 months after sowing.

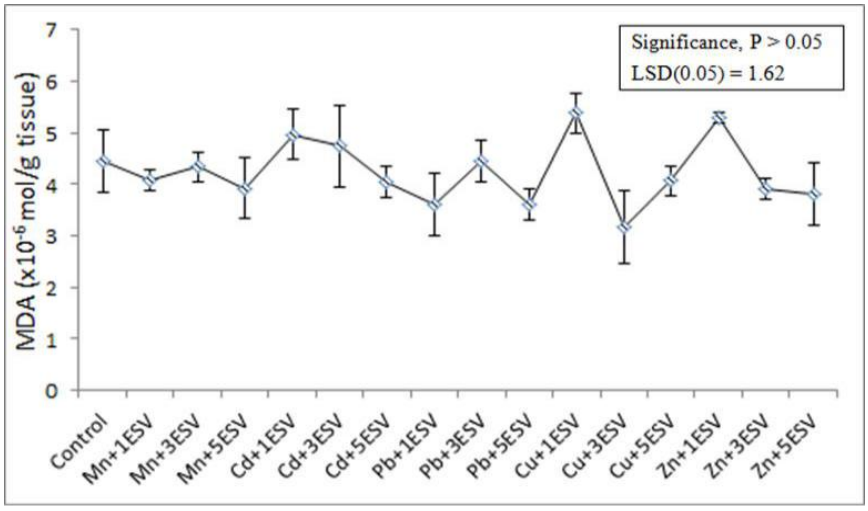


Fig. 5: MDA activity of leaves of developed *Chromolaena odorata* at 3 months after sowing

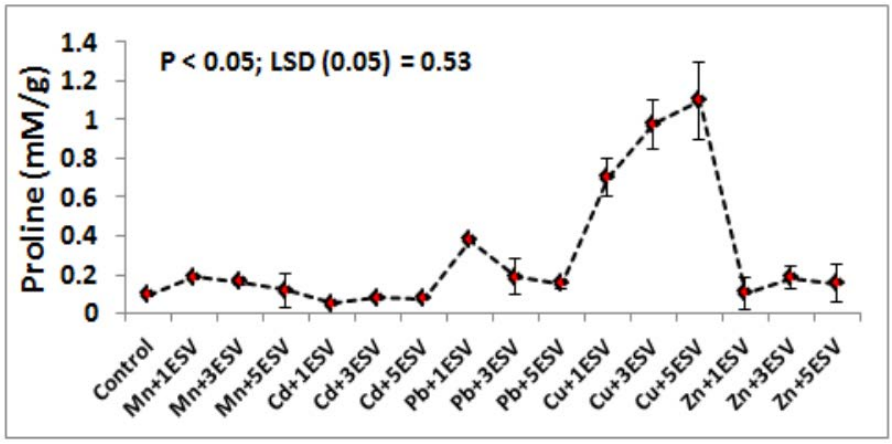


Fig. 6: Proline activity of leaves of developed *Chromolaena odorata* at 3 months after sowing

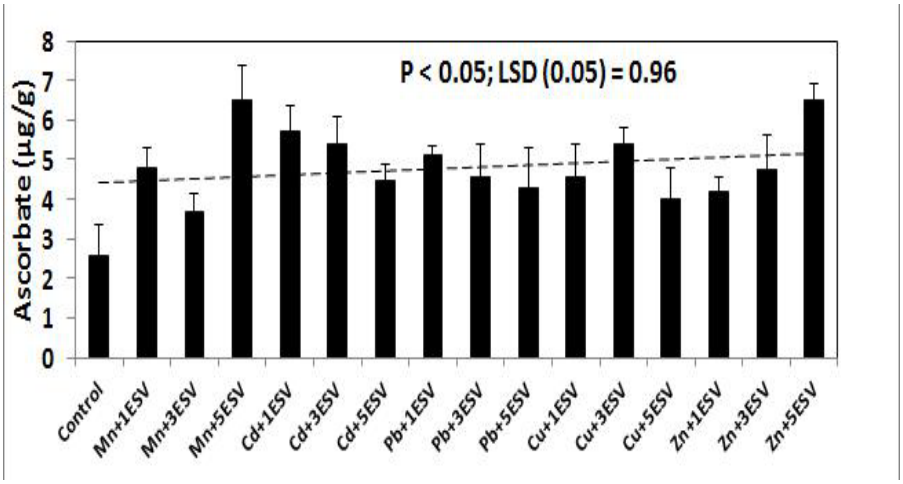
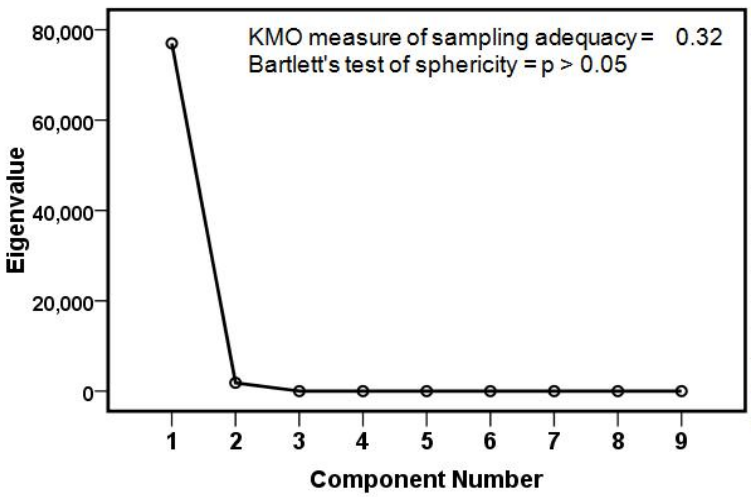


Fig. 7: Ascorbate activity of leaves of developed *Chromolaena odorata* at 3 months after sowing

Table 2: Correlation of selected antioxidants

	Hyd.peroxide	Lycopene	Carotenoids	Tocopherol	SOD	CAT	MDA	Ascorbate	Proline
Hyd.peroxide	1	-0.151	-0.233	-0.202	0.258	-0.284	0.065	0.252	0.217
Lycopene	-0.151	1	0.419	0.046	-0.025	-0.322	0.155	0.394	-0.269
Carotenoids	-0.233	0.419*	1	0.226	-0.188	0.157	-0.032	0.026	0.158
Tocopherol	-0.202	0.046	0.226	1	0.038	0.289	-0.097	0.071	-0.234
SOD	0.258	-0.025	-0.188	0.038	1	-0.385	0.15	-0.074	0.196
CAT	-0.284	-0.322	0.157	0.289	-0.385	1	0.143	-0.263	0.212
MDA	0.065	0.155	-0.032	-0.097	0.15	0.143	1	-0.159	-0.07
Ascorbate	0.252	0.394	0.026	0.071	-0.074	-0.263	-0.159	1	-0.138
Proline	0.217	-0.269	0.158	-0.234	0.196	0.212	-0.07	-0.138	1

* Correlation is significant at 0.05



Component Matrix[a]

	Component 1
Carotenoids	0.9999
Lycopene	0.4292
Hyd.peroxide accumulations	-0.233
Tocopherol	0.2258
SOD	-0.187
Proline	0.1539
CAT	0.1518
Ascorbate	0.0305
MDA	-0.03

Extraction Method: Principal Component Analysis.
a. 1 component extracted.

Fig. 8: PCA summary output for selected antioxidant

CONCLUSION

The presence of Zn, Cu, Mn, Cd and Pb enhanced foliar antioxidant activity. As earlier presented, increased antioxidant activity guarantees that the affected plant is able to survive the adverse effects of the heavy metal. *C. odorata* have been used in the remediation of heavy metal-contaminated soils. This heightened antioxidant activity resulting from heavy metal exposure is a sure proof of its heavy metal-tolerant capabilities.

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