

Review

Raising Awareness on Solid Waste Management through Formal Education for Sustainability: A Developing Countries Evidence Review

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Abstract: Solid Waste Management (SWM) is a multifaceted problem comprising political, socio-economic, institutional, and environmental aspects. Due to exponential urban growth, it has become one of the most significant issues faced by urban spaces in developing countries. The gap in environmental knowledge among the youth and the old within developing countries contribute to ecological issues or waste management problems, resulting in unsustainable development, with important consequences in low-income countries. For that matter, a systematic review was conducted aiming to identify and analyse environmental knowledge, awareness, attitudes, and practice studies on SWM from 2010 to 2019 in developing countries. The evidence suggests that students at both secondary and tertiary levels have positive environmental attitudes, and high awareness of environmental issues, but there is a lack of practical education of teachers to guide students to put SWM into practice. Student's low environmental knowledge is related to a deficiency in teachers' practical experience in SWM for environmental sustainability. A relationship between teachers' and students' knowledge and attitudes towards SWM, as well as differences in awareness, attitude, and practices of SWM linked with education and age, were also found. This review also revealed that the lack of environmental education in most developing countries is caused by fragilities in practical environmental curricula of teachers to respond to modern-day environmental issues for sustainable development and cleaner production (CP). To bridge the knowledge gap between the youth and older people in SWM, environmental sustainability education should be integrated into schools at all levels within developing countries.



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1. Introduction

Solid waste management (SWM) is a critical environmental problem with direct effects on both environment, e.g., air, water, and soil, and public health. The increase in waste generation across the world greatly complicates proper waste management activities [1,2]. Any non-liquid waste created by individuals, households, small businesses, or institutions outside of the waste generated within cities is referred to as solid waste (SW) and the uncontrolled disposal of SW may affect public health and the environment [3]. It is known that the collection rates of SW may vary significantly from one country to another. According to Hoornweg and Bhada-Tata [4], less than 50% of waste generated is collected in low-income countries: 50% to 80% is collected in middle-income countries, and more than 90% is collected in high-income countries. However, hardly anywhere is 100% collected. The rapid growth in urban populations, economies, and power consumption in developing countries, combined with the failure of institutional authorities responsible

for city planning, roadworks, SWM, and the environment to execute their core functional duties, has led to rampant SW generation [5–8].

SWM plays a vital role in minimizing the impacts faced by municipal and rural areas due to increasing urbanization [9]. It has become a major environmental challenge in developing countries due to the economic growth and the acceleration of consumption, which caused an expansion in SW generation. SWM systems in most cities of lower-middle-income countries are underachieving their goals, underperforming, and originating adverse sustainability effects in urban growth and development [10–13].

Nonetheless, since waste management is gradually considered a “basic human right” [14], there is a rising demand to improve SWM in cities in the developing world due to the rural-to-urban surge of migration. This need is linked to at least 12 of the 17 Sustainable Development Goals (SDGs) [14,15]. The increase in waste creation has caused a severe shortage of landfills and higher costs for waste management [16]. SWM is directly related to the circular economy, which are two basic concepts that have a crucial role in the 2030 Agenda, especially in SDG for sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12), and life below water (SDG 14) [17]. The Stockholm Environment Institute’s latest report, commissioned by the European Environment Agency [18], identified that, among the targets with the most substantial synergistic potential to make progress on SDGs implementation, is SDG target 12.4, which aims toward responsible management of chemicals and waste.

Most of the low/middle-income countries are unable to provide effective SWM collection services because of resource constraints, lack of facilities including vehicles, infrastructure, improper route planning, lack of technical know-how, and inadequate environmental education and awareness [19–23]. A study by Ikhlayel [24] reported that waste management is a complex sustainability issue that requires a clear vision and integrative approach in addressing its intrinsic association with many environmental and economic drives.

To sustain SW or environmental issues in developing countries, formal education for sustainable development is essential at all levels of education, able to trigger a whole societal transformation. For better environmental sustainability or waste management sustainability education, teachers with the right knowledge, attitude, skills, and innovation, are required. Accordingly, this study will review how formal environmental education in schools can help sustain SWM toward cleaner production (CP) in low/middle-income countries. As far as it is known, no similar systematic review has been made in this field, in the context of developing countries. A result from a search in the ScienceDirect database (2000–2020) reveals that 391 review papers have been produced in this area. However, none of these studies have associated the formal education and SWM practices in developing countries. Thus, it is expected that this review can complement the determination of decision-makers and solid waste management providers that aim to improve management system schemes in developing countries. Furthermore, this review aims to contribute to determining which factors need to be investigated further in future research in SWM, which are created in developing countries.

2. Literature Review

2.1. Solid Waste Management—Courses and Effects of Poor Management of SWM in Developing Countries

Waste is an unavoidable, unwanted material resulting from human activity [25]. It is generated from every human and animal habitat. It is considered as refuse of useless or worthless stuff, material to be discarded, or material that has no longer been used for any purpose by people within a specific locality, and can be classified into a solid, liquid, or gas. SW comprises sludge, garbage, refuse, and other solid materials that are discarded. It also includes SW from mining, agricultural, electronic, industrial, and municipal waste, which consists of household and commercial activities.

The pool of these different, unwanted, solid materials by cities from different types of household activities is known as SWM [26], representing a severe environmental problem in developing countries. It is expected that the cost of waste management in developing

countries will increase, which is a major source of concern. Scarlat et al. [27] indicated that 125 million tons per year of SWM were generated in Africa in 2012. The waste amount is expected to grow to 244 million tons per year by 2025 [28]. Due to the fast-growing economy, through industrialization and population growth, waste generation is projected to double or triple in most of the developing countries by 2050 [28]. Inappropriate management of waste in the municipalities of developing countries has led to polluted cities. Some of the problems associated with polluted environments include leachate, which contaminates both land and surface waters, with emission of methane (CH₄) and other gases. Lee et al. [29] found that more than 800 tons of carbon dioxide waste are released to the atmosphere yearly. Poor management of waste practice causes blocked drains, floods, transmitted infections via the breeding of vectors, and escalates respiratory issues through floating particles that result from the burning of waste [28,30]. In most studies reviewed, it has been acknowledged that rapid population growth (urbanization), inadequate human resources, lack of facilities such as vehicles and infrastructure, improper route planning, weak organizational structure, insufficient budget, weak legislation, lack of enforcement, low public awareness, corruption, conflict, political instability, and lack of political will [20,22,31], as well as other activities resulting from lack of government regulation, are the underlying problems affecting SWM in most developing countries. The main difficulty facing proper management of SWM is that one-third to two-thirds of SW generated is not collected [31–33]. This amount of uncollected waste pollutes the soil, water, and atmosphere, and the negative impact of the pollutants represent a significant health risk to animals, plants, and the human population [34].

The absence of an effective and comprehensive legislative framework governing the SW sector, coupled with inadequate enforcement mechanisms, creates gaps in SWM. A study from Khateeb et al. [35] has also shown that some of the developing countries without financial resources are lacking human and organizational capacities. As an example, most developing countries do not have monitoring mechanisms to check the waste that is generated to enhance planning at the various local, district, regional, and country-level holistically [36–38]. In recent times, modernized technological devices such as geographic information systems (GIS), radio-frequency identification (RFID), and international systems for mobile/general radio packet services have been developed to monitor the collection of bins and trucks [39]. However, this technology is virtually absent in all developing countries because of its high cost. This is a very important aspect of the entire technology issue related to SWM to be considered in developing countries.

Although some of the developing countries have the infrastructures and the needed facilities for proper collection, transportation, and discarding of SW, the institutions needed to build human capacities, and public awareness in the management of SW are not encouraging aspects of SWM, able to be handled by most developing countries [40]. SWM can be sustained with the support of formal education and awareness. For Ardoin et al. [41], environmental education is more than the unidirectional transfer of information, enhancing environmental attitudes, awareness, knowledge, and skills for an affirmative environmental action. The sustainability of SW can be achieved through effective environmental education both at school and outside school. Most of the authors involved in SWM studies reported that segregation of waste, which serves as a conduit for the sustainability of SWM, is not well practised or not done in most of the developing countries [11,42–44]. In municipalities where sorting was partially practised, gender and age were the predictive factors of this behaviour, i.e., it was observed that females appeared to be more active in waste separation than males, according to Sarbassov et al. [45]. The study of the same authors further indicated that two-thirds of sorted waste in the developing countries is done by the elderly (50 years and above), and no separation or a small amount is done by the age range of 5–17 years, while almost one-third of the segregated waste is done by people within the ages of 18–39. A report by the statistical department of South Africa [46] also highlights that young adults aged 18–24 years displayed far lower percentages of sorting than those aged 65 years and older. In Bogota (Colombia), Padilla and Trujillo [47] realised that older heads

of families demonstrate good environmental behaviour when it comes to the sorting of waste from source. In sustaining and managing SW within developing countries, attitude changes toward waste management and enhanced knowledge in the segregation of waste from the source are essential to reduce landfill problems. The sustainability of SWM can be realised in lower/middle-income countries through rigorous formal environmental education at all school levels, to close the gap in waste awareness between the elderly and the youth. SWM leads to the first hypothesis in this study.

Hypothesis 1: *The lack of teachers' practical environmental knowledge influences waste management.*

2.2. Teachers' Knowledge of Solid Waste Management

Education is one of the essential tools to create awareness among people, particularly in developing countries. According to Singhirunnusorn et al. [48], waste separation slightly improves with age. The elderly practice more waste segregation than the young. Other studies conducted within developing countries also indicate that most older generations are willing to sort out their waste [49–51] because they may become more aware of environmental consequences and value the planet. Environmental education is, thus, essential to bridge the gap in knowledge of the young and old in waste management segregation and waste sustainability in developing countries. For UNESCO [52], people's awareness about the environment and its accompanying challenges can be increased through environmental education. It develops the specified skills and expertise necessary to deal with the environmental challenges and promote attitudes, motivations, and commitments to form decisions and take responsible actions. The United States Environmental Protection Agency (EPA) [53] considers that environmental education comprises more than only information about the environment. It rather enhances critical thinking, contributing to solving problems, and allowing effective decision-making skills. Moreover, it increases public awareness, knowledge of environmental issues, and enables individuals to provide facts or opinions on environmental matters, aiming to take responsible decisions.

Environmental knowledge is a term used to describe concepts and behaviour patterns related to the environment [54]. Olsen et al. [55] believe that teachers are the primary keys to develop skills of knowledge in students using education to sustain human life, sustainable environmental behaviour, and achieve sustainable development. The upsurge in environmental knowledge raises the awareness of environmental problems, which may likely allow individuals to take action to protect the environment [56]. However, to solve the problem concerning waste management or environmental issues, the teacher's SWM knowledge is essential with particular emphasis in developing countries. Therefore, and through formal education, teachers may provide students with a knowledge base and a clear understanding of emerging environmental problems [57,58]. However, misinformation of students might come from incorrect opinions passed along by their teachers [59] with important future consequences.

A study conducted by Martínez-Borreguero et al. [60] indicates that teachers in developing countries lack practical knowledge of waste and understanding of what they teach. This is because most of the country's tertiary institutions that educate the teachers do not have a regulated curriculum for waste management. Studies by Galarpe and Heyasa [61] and Ifegbesan [62] indicate that teachers in developing countries have negative waste management practices because they have limited waste management knowledge and awareness. The awareness and knowledge of waste management or environmental issues depend on the teachers' area of specialization or qualification, and the kind of institution attended, coupled with the personal teaching experience [16,62], which is meaningful in developing countries.

Teacher's knowledge and awareness are very important when designed to promote sustainable education or environmental sustainability goals. According to Fien [63] and Sibbel [64], environmental education encourages sustainable lifestyles and discourages students' unsustainable lifestyles by providing them all the obligatory tools for widespread

positive societal effects. A study conducted by Colombo and Alves [65] indicated that sustainability could be joined to education through training programs. The contribution of teachers, students, and communities can have a positive impact on the cost of waste operations, and the investment in technology can ensure long-term benefits on the environment and sustainable development and CP in developing countries [66].

Due to the absence of viable environmental knowledge, most of the developing countries have seen their environment destroyed. The nonexistence of practical knowledge of SWM or environmental knowledge by most teachers within developing countries negatively influences students' knowledge environment and attitude toward SWM.

These considerations lead to the second and third hypotheses.

Hypothesis 2: *The lack of teachers' knowledge influences students' SWM knowledge and awareness.*

Hypothesis 3: *Students' environmental attitudes influence SWM.*

2.3. Students' Knowledge and Awareness of Solid Waste Management

Being aware of natural cycles is a huge step toward developing nature connectedness. This will be the first stage to raise environmental awareness. According to Anija-Obi [67], environmental education is a field of study that seeks to promote among citizens, not only awareness and understanding of the environment, but the relationship of man with the environment and mandatory actions of responsibility to allow survival, while improving the life quality standard. Students' SWM knowledge and awareness is important for waste sustainability in most developing countries. Some researchers have shown that early childhood experiences affect children's cognitive and emotional benefits and influence the development of lasting environmental attitudes and behaviours [68–70]. A study by Evans et al. [68] indicates that children understand the ecological and human impacts on the environment from environmental problems awareness.

Research by Tikka et al. [71] indicates that education influences environmental awareness and attitude. Most students in the developing countries do not have the practical knowledge to enable the practice of correct waste management in their schools and, at home, to impact their family's knowledge due to the lack of teachers' knowledge. Environmental education in recent years has been taught in the curriculum levels of education in most of the developing countries, but the practical knowledge from teachers to students is minimal. As a result, this has created gaps that lead to lower standards in managing waste for sustainability in most developing countries. A case study by Panko and Sharma [72] indicated that submerging students into practicalities of environmental education, i.e., waste management, enhance a profound understanding of the broader principle of knowledge and attitudes to be acquired. Sustainable and effective waste management can be accomplished within developing countries when a conscious effort is put into developing the curriculum levels of education and teachers, giving the necessary training in practically imparting knowledge and creating awareness in students. For developing countries to achieve 12 of the 17 SDGs (Sustainable Development Goals) of the 2030 agenda, waste management, accomplished through environmental education, must be practically oriented [15,73]. For SW sustainability, developing countries' governments must enforce waste segregation at all levels of schools for better behavioural and attitudinal change and bridge the knowledge gap between the old and the youth in the management of waste.

2.4. Environmental Attitude—Students' Attitudes Towards Solid Waste Management

Environmental attitudes refer to people's favourable or unfavourable feelings regarding some characteristics of the physical environment. Fabio and Kenny [74] believe that people's attitudes toward the environment and the type of concern they develop toward it are associated with the degree to which they view themselves as being interconnected with nature. This will have consequences in the sustainability level to be achieved in the entire country.

Studies have shown that environmental attitudes of children are formed roughly at the age of twelve [70,75–77]. That is why children should be taught with a positive attitude toward SWM, through environmental education, which will teach children to respect the environment and its resources. For that matter, the environmental attitudes of young people must be critical as they ultimately play a direct role in providing knowledge-based solutions to emerging environmental problems [78,79]. Meanwhile, if school environmental programs are directed at students, and they are formulated appropriately, they can impact the environmental knowledge, attitudes, and behaviour on adults, i.e., parents, teachers, and local community members, through the process of intergenerational influence [80,81]. A study conducted on environmental knowledge and attitudes also shows that students can develop high levels of understanding and positive attitudes, thanks to their families, teachers, school curriculum, and through reading studies and information regarding the environment [79]. In that case, teachers' mental attitude in environmental education toward waste management is vital in teaching students in the context of developing countries.

A positive attitude toward environmental education can reduce the disparity in waste management between the youth and the aged in developing countries. Every school generates waste from routine activities such as classwork, sweeping, serving food, and bush cutting. It is expected that, as part of the learning process, waste management activities in schools will involve students by building the right attitudes toward waste management in developing countries.

3. Understanding Cleaner Production for Sustainable Transformation

The willingness to understand the environment through education is one of the important key steps in finding lasting solutions to environmental problems such as SW, pollution, degradation, deforestation, energy, and others, caused by mankind and compromising sustainable development and CP.

CP is an environmental preventive approach to waste reduction and energy efficiency aiming business profitability [82]. Hence, understanding waste minimization sustainability requires a new attitude, additional knowledge, and skills from students and academics. According to Abdul-wahab [83] and Katherine et al. [84], integration of CP into the environment curricula is an important strategy for the understanding of nature, technology, and economy, from the university to the lower level of education, so important in developing countries.

In developing countries, the level of awareness of CP programs among professionals, companies, and stakeholders is low [85,86]. This is because students, employees, and public authorities are not trained toward sustainable CP. Universities that bear the responsibility of training for transformational changes in CP techniques such as technology, waste use, operation practices, materials input, and packaging [87,88], are not resourced enough to create awareness, knowledge, technologies, and tools to achieve a future environment within the developing countries [89]. Therefore, if students in the developing countries are educated effectively on CP, the cost of managing waste disposal, raw materials, and energy will reduce, which will positively affect the environment and significantly influence the economic savings in most of these countries [90,91]. Therefore, CP should be introducing gradually at all levels of education for better awareness, considering that a late positive environmental attitudinal change is difficult to achieve.

4. Sustainable Waste Management Gap Bridging

Educating students on environmental sustainability remains necessary for a healthy and stronger environment. A study conducted by Agut et al. [92] reports that, to achieve sustainable living, early environmental education is necessary. This is because children build their own identities at a primary age [93]. Given that sustainability education in the primary parts of students' life, it is crucial to equip or build them with the kind of knowledge, attitudes, awareness, and skills to protect the socio-economic environments of both present and future generational leaders [94]. A study in the United States showed

a significant relationship between age and waste source separation. More than 62.5% of urban waste separation aiming sustainability is done by older people [95]. Research in other parts of the world also indicates that the older age groups tend to sort and manage household SW by themselves, whereas the younger residents allow waste management services to perform the separation [50,96]. To bridge the knowledge gap between the youth and older people in managing waste to achieve environmental sustainability, formal environmental education is necessary for early childhood education, which will lead to greener waste practices and to CP. This formal education must be practically oriented up to university levels with the teacher as the pivot for implementation of sustainability learning.

5. Barriers to SWM Sustainability in Schools

Implementation of SWM sustainability in schools within the developing countries encounters several major barriers. Some of these challenges include the lack of resources, absence of qualified administrators or trained teachers, logistics, and the nonexistence of students' commitment, interest, and sustainability awareness.

The lack of resources affects time and money. Schools and institutions within the developing countries lack the funds [97,98] to support significant and meaningful sustainable interventions. This is because the institutions and governments in most developing countries do not prioritize sustainability activities. Hence, schools are deprived of the required funds for effective practice.

Another barrier for SWM sustainability implementation in school is the absence of teachers and administrators to support sustainability. According to Herrera et al. [99] and McIntosh et al. [98], sustainability cannot fully be implemented in schools and institutions unless administrators and teachers work hard to promote it. Due to the lack of specialized teachers for effective teaching of sustainability in the developing countries, the practice of SWM sustainability leading to CP, will be delayed. The logistical barrier also affects the implementation of SWM sustainability in school. Most schools in developing countries do not have access to any tools and materials, such as data tracking systems, bin sorters, and other items necessary to improve an effective SWM.

Lastly, there is a lack of commitment from teachers and experts to engage and create a sense of awareness, knowledge, and attitude toward students' interest in sustainability [100], which is one of the main barriers in developing countries. Because the change in attitude is difficult, leaders in developing countries' institutions or schools must work toward sustainable development by introducing citizens to sensitizing environmental research and promoting sustainability activities.

6. Materials and Methods

6.1. Type of Study

A systematic review of the scientific literature was conducted, selecting relevant studies in the field. The systematic review was performed according to Khan et al. [101] guidelines. This review aims to give a contribution to the following research hypotheses.

Hypothesis 1: *The lack of teachers' practical environmental knowledge influences waste management.*

Hypothesis 2: *The lack of teachers' knowledge influences students' SWM knowledge and awareness.*

Hypothesis 3: *Students' environmental attitudes influence SWM.*

6.2. Search Strategy

A search was performed to find studies in multidisciplinary databases such as Scopus, Emerald Publishing (CFT1), Medline/PubMed, Springer, ERIC, and Google Scholar content aggregator. The syntax used to search for the articles was "solid waste management" AND "Teacher knowledge" AND "attitude" AND "environmental awareness" AND "formal education."

6.3. Selection of Studies

The combination of syntaxes such as SWM, environmental awareness, environmental education, environmental sustainability, and students' attitudes toward waste and other additional search terms resulted in a significant number of findings. To choose appropriate studies for this review, the study obeyed the following criteria. The inclusion criteria were: articles published between 2010 and 2019, containing empirical data, published in peer-reviewed scientific journals, focused on knowledge, awareness, attitude, and practice, involving students at all levels, and studies focused on developing countries. The countries were considered as developing because they either have less than 0.800 human development index (HDI) in the United Nations Human Development [102]. Although Malaysia has an HDI value of 0.804 [102], it is considered as a developing country due to low gross domestic product (GDP) per capita income (below 25,000 USD) and due to the low level of industrialization, when compared with countries classified as developed [103]. Philippe Ithurbide [104] also considers Malaysia as a non-developed country due to regular sharp depreciation of its currency, which led to an increase of debts for the country. To remove duplicates from the studies, a rigorous literature screening process was performed using Mendeley bibliographic software and also by manually further analysing the various articles identified by the software.

6.4. Data Collection and Analysis

The study variables were country, year, size of the sample, data collection methods and findings and variable factors that consisted of knowledge, attitudes, practices, awareness, gender, and age for which the extraction was completed on the Microsoft Excel 2019 spreadsheet.

7. Results

The preliminary search finding identified 17,821 articles. This search was then reduced to 128 when the main used keywords were combined together. After applying the inclusion criteria of the studies developed in developing countries and the removal of duplicates, 37 studies remained. Through a laborious literature screening procedure, 23 of the studies that focused on teachers' and students' knowledge, awareness, and attitude towards SWM in developing countries, were selected. The reviewed studies were conducted in Kenya, Ghana, Nigeria, India, South Africa, Philippines and Malaysia, China, Vietnam, Bangladesh, Ethiopia, Nepal, and Indonesia. These studies consisted of teachers ($n = 110$), students ($n = 9970$), and community members ($n = 512$) with a total of 10,592 individuals. Self-administered questionnaires were used in each studied article to collect data. Articles were analysed systematically, and detailed information on the articles are presented in Tables 1 and 2.

The summary of the analysed studies presented in Table 1 indicates that 22 studies were conducted in schools, except for the study of Shewasinad et al., and Twumasi [110,115], which surveyed their community. The variables presented in Table 1 can be grouped into three main dimensions. These are psychological variables, i.e., attitude, behaviour, situational variable, i.e., knowledge, awareness, age, gender, and participation variable, i.e., practice and communication.

The summary of the analysed studies presented in Table 2 also indicates the findings of the articles and the challenges.

Table 1. Summary of the analysed studies.

Study	Country	Variables That May Influence and Determine Sustainable Waste Management/Environment	Method to Collect Data/Sample Size
Madrigal & Oracion [105]	Philippines	Awareness, attitude	survey/563
Ahmad et al. [106]	Malaysia	Knowledge, attitude, practice, communication	survey/895
Paghasian [107]	Philippines	Awareness, practice	survey/253
Adeolu & Enesi [108]	Nigeria	Attitude, practice, knowledge, age	survey/400
Gustria & Fauzi [109]	Indonesia	Awareness of student	mix-method/65
Shewasinad et al. [110]	Ethiopia	Attitude, knowledge, practice	survey/392
Licy et al. [111]	India	Attitude, practice, knowledge	survey/300
He et al. [112]	China	Knowledge, attitude, behaviour	survey/223
Phan Hoang & Kato [113]	Vietnam	SW knowledge	survey/247
Karpudewan et al. [114]	Malaysia	Knowledge, awareness	survey/110
Twumasi [115]	Ghana	Awareness, practice	survey/120
Boiyo et al. [116]	Kenya	Attitude, behaviour	survey/164
Aduku [117]	Ghana	Attitude	survey/400
Niekerk [118]	South Africa	Awareness, knowledge, practice	survey/815
Sultana et al. [79]	Bangladesh	Knowledge, attitude	survey/300
Dung et al. [119]	Nigeria	Knowledge, attitude	survey/1800
Kalsum & Isa [120]	Malaysia	Awareness, behaviour	survey/186
Pavliukh [121]	Turkey	Awareness, sensitivity	survey/212
Abdullahi & Tuna [122]	Nigeria	knowledge	survey/470
Ifegbesan et al. [123]	Nigeria	Awareness, age, agenda	mix-method/840
Varoglu et al. [124]	Turkey	Awareness, attitude, behaviour, illiteracy	survey/335
Müderrisoğlu & Altanlar [125]	Turkey	Attitudes, behaviour	survey/507
Singh et al. [126]	Nepal	Awareness, knowledge, attitude, practice	survey/434
Liao & Li [127]	China	Knowledge, behaviour	survey/562

Table 2. Synthesis of the analysed study's objectives and main findings.

Study	Summary of Objective and Findings of Research Articles
Madrigal & Oracion [105]	Madrigal conducted a study in SW awareness, attitude, and practice with 563 students and employees of Catholic higher education in the Philippines and concluded that the respondents had high SWM awareness, attitude, and practice. There was a significant difference in awareness, attitude, and practice when it comes to status and religion, but significantly related in terms of age and education.
Ahmad et al. [106]	A study was conducted to determine the relationship between students' environmental knowledge, attitude, communication, and practice of the 895 higher level institution students. The study revealed that students were knowledgeable about the environment, but the knowledge did not lead to practice. For environmental sustainability, the study showed a weak relationship between students' knowledge, attitude, and practice. The study also suggested social media and families as another means of spreading environmental practice information. The school did not have materials for waste sorting practice.
Paghasian [107]	253 students were randomly selected to investigate the significant relationship between SWM awareness and practice. The study indicated that awareness was high, and there was a good practice concerning separation, reduction, and recycle. SWM awareness had no influence on the practices of disposal but affected the student practices on sorting, recycle, reduce, and reuse.
Adeolu & Enesi [108]	This study aimed at investigating the knowledge, attitude, and practices of 358 students in the secondary school in Ibadan, Nigeria, toward waste management. The results showed that students' knowledge, attitude, and practice of waste management were moderate. The study indicated a high number of improper disposal of waste at every space. The results showed that gender and age significantly influence knowledge, awareness, and practice of waste management.
Gustria & Fauzi [109]	A study was conducted to measure environmental literacy on knowledge, awareness, and concern with 66 selected senior high students in Indonesia. The study indicated that 80% of the students were considered as having inadequate environmental literacy. The lack of understanding was due to limited information and inappropriate lesson plans for the study.
Shewasinad et al. [110]	A total of 392 Kometa kebele community members were randomly selected to assess knowledge, practice, and attitude toward waste disposal management in South West Ethiopia. The results indicated that the majority of people have good knowledge, a positive attitude, and good practice toward waste management. Most of the respondents were married and also female.
Licy et al. [111]	A study was conducted to assess waste management practice information among school children in Kerala. Using a well-structured questionnaire, 300 students were randomly selected for the studies. The result showed that high school students are more aware of waste when compared to high secondary students. The results also indicated a significant difference between awareness and practice. The study revealed the need for massive awareness of waste practice from the beginning of school as well as the urgent need to rectify the knowledge and practice gap in waste management.

Table 2. Cont.

Study	Summary of Objective and Findings of Research Articles
He et al. [112]	The study was conducted to determine environmental awareness in two regions of contrasting levels of economic development and environmental problems in China. The data obtained from the university results showed that all the students sampled had low levels of environmental knowledge but a positive attitude and were also environmentally-friendly. A student growing up in developed and less-developed settings had significantly different levels of environmental awareness.
Phan Hoang & Kato [113]	In January 2014, a survey of 247 students was conducted in DA Nang city. Two elementary school students' knowledge of SWM were assessed. The results in February 2015 indicated that 96% of the student developed an absolute interest in SWM activities. The study also resulted in a change in student knowledge after environmental education for a year.
Karpudewan et al. [114]	A survey was conducted to investigate the level of awareness and understanding of traditional environmental concepts and sustainable development concepts among pre-service teachers. The result of the 110 pre-service teachers indicated that knowledge of sustainable development and awareness was low, when compared with the understanding of traditional environmental concepts. The study confirmed a sustainability knowledge gap in sustainable development knowledge.
Twumasi [115]	The objective of the study was to find information about waste management practice within a community in Ghana. In the survey, 120 people were randomly selected to respond to a well-designed questionnaire. The results indicated that most people were aware of SWM but never put it into practice. People's attitudes toward a social commitment to waste participation were weak. The researcher noticed that e-waste awareness was absent in the community and it was necessary to rectify the knowledge and practice gap.
Boiyo et al. [116]	A study was conducted with 320 students who were randomly selected to determine the relationship between attitudes and environmental participation in the urban area of Nairobi. The result showed that attitude and level of environmental participation did not influence each other. The study also revealed a positive connection between attitude and ecological behaviour.
Aduku [117]	This research was conducted to examine the attitude and knowledge of junior high school toward an environmental condition in public schools in the Ga West metropolis of Ghana. A total of 400 students was used for the research. According to the result, students have a poor attitude toward sanitation and different environmental behaviour within each school studied. The research found a gap in knowledge of sanitation by the student.
Niekerk [118]	This study examined 815 students' level of SWM awareness, knowledge, and practice. The study used descriptive statistics to analyse it. The results indicated that students were aware of concerns of waste management practice in their schools and the communities, but had poor waste management practice with negative impacts on the country. The study indicated that waste management practice activities were minimal in schools and the environment. The research indicated that students were the key agent of change toward a more sustainable future. Therefore, young people should be engaged to improve their knowledge of environmental issues.
Sultana et al. [79]	This study used 300 students from both public and private schools to assess the environmental knowledge and attitude in the Tangail district from January to April 2015. The study revealed that the level of environmental knowledge depends on the program offered in schools. Student attitude toward the environment is higher in public schools, when compared with private schools. With gender, environmental knowledge and attitude had a substantial difference. The students from an urban area have higher environmental knowledge while the rural student has a better environmental attitude. The study also showed that students' environmental awareness is influenced by parents' educational level. In conclusion, the students' level of understanding and positive attitude may be achieved from families, media, teachers, and reading.
Dung et al. [119]	This study was conducted to assess the knowledge and attitude of students' toward SWM. A sample size of 1,800 colleges of education students of the North Central zone of Nigeria was used. The finding indicated that students had low knowledge and a positive attitude toward SWM. A significant relationship was found between students' knowledge and attitude toward SWM. Gender has no major influence on knowledge and attitude toward SWM.
Kalsum & Isa [120]	A total of 186 university academic staffs were surveyed to determine the connections between knowledge, attitude, behaviour, and level of awareness to the principles of a sustainable campus. The result indicated that the staff have a high awareness level about principles of a sustainable campus, but a weak correlation between awareness and behaviour.
Pavliukh [121]	A study was conducted to determine environmental sensitivity and awareness of university students. A survey that was applied to 212 students indicated that environmental awareness and behaviour were lower even though courses on environmental issues were taken. The study concluded that environmental knowledge does not influence awareness and behaviour.
Abdullahi & Tuna [122]	In this study, 470 students were surveyed from secondary schools, universities, and colleges in Nigeria, to investigate students' knowledge and perceptions. The results revealed that the knowledge of environmental issues was not satisfactory, but perception toward the environment was good.

Table 2. Cont.

Study	Summary of Objective and Findings of Research Articles
Ifegbesan et al. [123]	A study was conducted to determine the practice of SWM in public secondary school. The results showed an overall positive level of awareness, attitude, and practices of teachers toward SWM, but the practice was better in some schools, when compared to others.
Varoglu et al. [124]	Environmental literacy, attitudes, awareness, and behaviour studies were conducted among 335 middle school students in Eskişehir to determine the effects of purchasing good environmental products. The study showed that environmental illiteracy has no major effect on the attitude and purchase of environmental products, while awareness has a positive effect on a pro-environmental attitude toward environmentally-friendly purchased products. The results also showed that students develop positive attitudes toward the environment through awareness. In addition, a positive environmental attitude leads to pro-environmental behaviour and adaptation of environmentally-friendly products.
Müderrisoğlu & Altanlar [125]	A study was conducted with 507 undergraduate students from the Abant Yzzet Baysal University toward attitudinal and environmental behaviour issues. The findings reported that university students were aware of the importance of waste management. The findings further indicated that the department area and gender have affected students' environmental attitudes and behaviour.
Singh et al. [126]	Studies were conducted to assess the awareness, knowledge, attitude, and practice regarding medical waste management. A total of 434 undergraduate dental students in five different institutions was used in Nepal. According to the results, the students had a positive attitude. Knowledge of biomedical waste was high and more than 50% of the students are unaware of government guidelines on biomedical waste. In terms of medical waste disposal, there is a lack of strict protocols since not all students are aware of disposal techniques.
Liao & Li [127]	In this investigation, 562 students were used to explore the understanding of Chinese high students' motivation toward the separation of SW on campus. The Theory of Planned Behaviour including environmental education and knowledge was used for the explanation of waste separation. The results indicated that environmental education is essential for students to acquire knowledge and a positive attitude toward the separation of SW on campus. Knowledge was the best predictor in student's separation behaviour.

7.1. The Variables Behind Solid Waste Management

The analysis of the variable from Table 1 and the summary results of Table 2 will take into account the three previously designed theoretical hypotheses, H1 to H3.

7.1.1. Attitude Variable

Attitude is a set of values and feelings acquired to motivate and contribute to environmental development and protection [128]. According to Ahmad et al. [106] (p.285), "knowledge forms attitude, and both knowledge and attitude are the building blocks for practice." The same study describes that attitude is measured through students' awareness and beliefs. The way to measure attitudes is by focusing on a person's assessment of whether the participation in the data was positive or negative.

Attitude is a critical element that influences SWM participation in schools and communities within developing countries. This is because positive attitudes toward SWM might increase the likelihood of involvement in waste management. The review showed that students had a high attitude toward waste management [105,109,112,116,119,125,126,128], which confirmed the third hypothesis. However, other studies found the opposite [115,117], which results in indiscriminate disposal of waste that undermines the environmental health status of schools and residents. In the study to determine environmental attitude and ecological behaviour, it was found that there was no significant correlation between attitude and the level of participation in environmental activities [106,116].

SWM in schools and communities seems to be low, despite high or positive attitudes in developing countries, due to some of the following barriers. The lack of teachers with practical and specialized knowledge to teach and train students with the right approach to manage waste, and the lack of funds to buy adequate technological facilities to manage waste is considered to be the biggest barriers to SWM awareness. Attitude can influence the participants of SWM studies in schools, universities, and communities within developing countries.

7.1.2. Knowledge Variable

Environmental knowledge is considered as one's capacity to recognize symbols, concepts, and behavioural patterns related to environmental protection [54,129]. An increase in knowledge will enhance the concerns of people's awareness and attitudes toward the environment [130,131]. Karpudewan et al. [114] stated that knowledge determines the attitudes and behaviour of an individual and should "... convince people to carry their intention to change, by giving a lot of attention to attitudes, subjective norms and perceived behaviour control." (p.118). However, a change in perspective does not necessarily result in a behavioural change [132,133]. The lack of environmental knowledge may hamper the adoption of pro-environmental behaviour [134] or lead to wrong environmental decisions [135].

Knowledge is considered extrinsic in this context in which one can gain or acquire through an external source, such as in schools and universities. Most of the analysed studies [108,112–114,119,122] found low knowledge of SWM, while others [79,106,110,126] indicated a high knowledge level of SWM or environmental education. However, and as seen by the analysed results, knowledge does not necessarily lead to practice. Ahmad et al. [106] found that students with vast SWM knowledge had fragile practice, which supports the first hypothesis that the lack of teachers' practical environmental knowledge influences waste management. Hence, there is a gap between knowledge and practice of waste management among students [126] in developing countries.

7.1.3. Solid Waste Management Awareness Variable

Awareness, which can be defined as the perception or knowledge of an event, is accepted as the initial step, performing a requisite function in probable behavioural change and successful education, particularly when related to environmental issues [115,136].

It has been shown that the students' awareness of environmental problems and solutions can be increased through education [137]. For example, several studies [107,111,120,128] have shown a high SWM awareness. However, it is expected that SWM activities on the schools' campus should involve students as a part of their learning process, considering there is a significant difference between awareness and practice [111]. The cited studies confirm the second hypothesis, which states that the lack of teachers' knowledge influences students' SWM knowledge and awareness. The appropriate skills and awareness obtained through the correctly guided environmental study would assist in changing human behaviour toward the environment [106], which is very important in developing countries. For Pavliukh [121], environmental knowledge does not always influence awareness and behaviour. That is why students must be early motivated to participate in environmental protection activities and plans [138].

7.1.4. Solid Waste Management Students' Age Variable

Age is considered to be one of the essential variables concerning environmental education. According to Adeolu and Enesi [108] and Madrigal and Oracion [105], awareness, attitude, and practice were significantly related to age in SWM. This means that older age managed waste well. Students with a higher level of education managed the waste better than the lower level. Hence, the SWM knowledge of a university student cannot be compared with secondary and primary school students.

8. Discussion

This review allows us to conclude that there is generally an SWM positive attitude and high awareness. This should mean that an SWM positive attitude and perception must influence the practice or participation of the SWM in schools [139,140], which may lead to environmental or SW sustainability. A study conducted by Arı and Yılmaz [141] to examine the effects of ecological literacy, environmental awareness, and environmental attitudes among middle school students found differences. The study indicated that environmental literacy did not have a statistically significant impact on environmental attitudes. In most of

the developing countries, SWM practice has no corresponding effect with high awareness and no correlation or influence on attitudes toward waste participation or practice for sustainability, and these findings are extremely alarming. Studies conducted by Babaei et al. [50] and Yildiz et al. [142] indicate that awareness and attitude toward SWM problems or environmental issues do not change spontaneously. The change in a positive attitude toward SWM or environmental issues can occur through practical education, change of perception, social responsibility, and incentives or motivation through students' /teachers' rewards. According to Zsóka et al. [143], there is a correlation between environmental knowledge and awareness of environmental issues. This implies that knowledge and attitude may regulate the course of one's environmental action. Hence, students' environmental knowledge and environmental attitudes may lead to environmental participation for CP and environmental sustainability. However, it was also found that having a good level of attitude toward SWM could not be reflected in practices, as the study of Ahmad stated [106]. This evidence is not new and previous studies have also demonstrated, such as the study of Tatlonghari and Jamias [144].

Second, these review findings highlight an opposite position: profound knowledge of SWM or low environmental knowledge by students about waste management or environmental issues. Low education can lead to a possible change in attitudes toward environmental anxiety and awareness of sustainability. People with more education tend not only to be more concerned about the environment but also to be engaged in actions that promote and support political decisions designed to protect the environment. This is vital to start a movement to push governments toward the type of binding agreement needed to reduce greenhouse gases and control emission levels, dramatically affecting the global environment and climate change. However, behavioural change does not necessarily affect attitudinal change [145]. Hence, a lack of environmental knowledge or poor SWM knowledge may discourage the adaptation of a pro-environmental behavioural change [146]. The correlation between environmental knowledge and environmental attitude is significantly positive [147]. The deficiency of students' environmental awareness from various educational institutions in developing countries is due to a lack of practically oriented sustainable environmental knowledge by teachers to impact technical expertise to the student, encouraging the attitudinal change toward sustainability. This implies that environmental knowledge is the key to a clean environment and global environmental sustainability. Hence, students' environmental knowledge in developing countries can be enhanced when teachers are equipped with the necessary information, aiming to achieve a better sustainable environmental education.

Moreover, this review article revealed a significant difference in SWM's awareness, attitude, and practices, when linked to education and age. It was found that the understanding of SWM or environmental issues, awareness of the environmental problems, and attitudes toward environmental sustainability issues were associated with the students' educational level, age, and the geographical location of the studies. Younger participants, due to less experience in the field and less education, may be less open to receiving information about SWM, when compared to older age. However, the same result was achieved about environmental attitude. This suggests that higher environmental awareness, environmental attitude, and practices committed toward environmental issues related to environmental sustainability are important to achieve overall sustainability [105,108,148,149].

This review also revealed that the lower level of students' environmental knowledge or SWM knowledge is a result of a lack of the teacher's knowledge in SWM or environmental education. According to Jafer [57], teachers must provide students with knowledge based on a clear understanding of environmental problems for sustainable development. This implies that a lack of environmental knowledge among teachers strongly affects the implementation of environmental education at all school levels. The few students with a good understanding of SWM had a weak relationship between knowledge and sustainable environmental practice [106].

This study sought to establish that teachers' environmental knowledge influences how waste is practised and managed in schools, which is in agreement with the second hypothesis. Most teachers in developing countries lack practical environmental knowledge to impact positive environmental education in students, which will contribute to enhance environmental sustainability. It must be highlighted that the developing countries do not have the facilities and technologies for practical studies of sustainable waste management.

Analysing the results found in this study, it can also be concluded that teachers play essential roles in environmental education and sustainability, and these roles help to transform schools and society as a whole [148], specifically in the context of developing countries. The absence of adequate environmental education in most developing countries is caused by a lack of effectiveness and need serving curricula to respond to current environmental issues for sustainable development. According to Musthofiyah and Lailiyah [149], environmental problems can be solved by developing curricula activities within schools that could bring a positive impact on the environment. However, the lack of teachers' environmental knowledge influences the students' understanding of environmental sustainability. Salas-Zapata et al. [150] considered sustainability as the integration of environmental principles in human activities. Teachers' education has a significant role in the processes of sustainability, according to Nousheen et al. [151]. The author of the same study found that most students showed positive attitudes and awareness of environmental issues, active participation, or the practice of environmental education, which leads to environmental sustainability programs, such as conservation and protection of the environment as well as recycling, which are not always available in developing countries.

This review findings have also clarified some open problems and challenges of SWM or environmental issues that may affect and prevent implementation of SWM sustainability or environmental sustainability in schools within developing countries. Some of the barriers are the lack/inexistence of finance to promote sustainability, absence of trained teachers in sustainability issues, and the nonexistence of knowledge, awareness, practice, and interest of sustainability to achieve overall sustainable development. This suggests that SWM sustainability or environmental sustainability barriers can be overcome in schools when governments and other agencies are able to financially support sustainability projects in schools, train teachers to improve on sustainability knowledge, aiming to enhance the cleaner production effectiveness. Schools in developing countries are formulating curricula to promote sustainability through practice, awareness, and involvement, leading to sustainable development and cleaner and greener production.

To be able to achieve future sustainability in developing countries, teachers' education in sustainable development is the most important factor for upcoming generational leaders. Hence, teachers' knowledge, awareness, and attitude toward sustainable development should be enhanced through sustainable training such as workshops, research, conferences, and other capacity building information that can be practically transferred to students for now and for future sustainability. Financial constraints on financing activities and policies related to environmental sustainability for sustainable development and CP at all levels of the school must be a focus within developing countries. Stakeholders, governments, and other agencies must invest in schools' sustainable development for students for now and for future sustainable practice and participate in sustainable development activities for cleaner and greener production. This review is also able to positively contribute to improve managerial implications within sustainable development in developing countries by providing a synthesis of the current evidence in this topic, which can then be used at a local government and municipal level. Several studies have demonstrated that SWM managers make better decisions when inserted into an integrated framework [152,153].

9. Conclusions

Waste management related to overall environmental issues is a significant problem in most developing countries. This review article found that waste sustainability or environmental sustainability could be achieved in developing countries when environmental attitude, environmental awareness, and environmental knowledge are connected or communicated from teachers to students through formal education. Other conclusions able to be drawn from this article indicate that a high level of awareness and positive attitudes of students toward the environment did not influence the participation of environmental issues, which is contrary to the third hypothesis that states that positive student attitude affect SWM. Environmental knowledge and attitude levels were shown to be inconsistent with the students' practice level, which was lower. However, this third hypothesis can be supported and changes accomplished through practical education, motivation, or incentives, and social responsibility of teachers to students for environmental sustainability. The absence of students' environmental knowledge may impact behaviour and environmental, attitudinal change, which will affect overall sustainability in developing countries. The correlation between environmental education and environmental knowledge of students is essential in developing countries, aiming to achieve CP and environmental sustainability. Formal education will help create awareness for efficient and effective sustainable development, which is essential in developing countries.

The research further indicates that there is a significant difference between awareness, attitude, and practice when it comes to education and age. Age and education are directly proportional to environmental attitude, knowledge, and practice when it comes to environmental sustainability issues. According to the review's results, the lack of teachers' environmental knowledge influences the knowledge of environmental issues, which positively supports the previous first and second hypotheses, i.e., that lack of teachers' practical environmental knowledge influences waste management sustainability, automatically impacting students' SWM knowledge and awareness or environmental issues. Within this study, the reviewed articles show that students with either high or low knowledge in SWM or environmental issues have a fragile practice in terms of sustainability. However, teachers' core obligations are to teach and provide students with environmental knowledge based on clear understanding of sustainability issues. Hence, the lack of teachers' environmental knowledge will negatively impact the students' level of environmental issues toward achieving sustainability aiming CP. Teachers' knowledge is essential for sustainable development of students and it is the key to a sustainable future in the context of developing countries. Lastly, it can be concluded from the results that the absence of environmental education in most of the studied developing countries is due to the deficiency of up-to-date environmental curricula to respond to current environmental issues.

From this review, a link can be established with the main social and environmental challenges that world societies, and the developing countries in particular, are facing. It would be a big step if the priority of these nations was to fight the existing environmental problems, triggered in part by climate change and also by demographic pressure. Although these populations are struggling to have their basic needs fulfilled, such as food, education, health, and habitation, environmental issues represent an enormous source of concern due to the consequences it has to these specific countries. Being aware that humans are part of a larger interdependent ecosystem, these disadvantaged conditions make these populations more vulnerable to environmental problems, such as those related to the reported ineffective SWM practices. The poor state of SWM and other known and acknowledged environmental and public health issues in the context of developing countries can be addressed by bridging the environmental knowledge gap through practically oriented environmental education in schools. Practical environmental knowledge through activity-based curricula at various tertiary institutions that train teachers, carrying out regular workshops and conferences with teachers, will positively contribute to develop teachers' curricula and shape the knowledge and attitudes of students toward global environmental sustainability in these countries.

Limitations are present in this systematic review. One of the limitations of this study is the possibility of environmental bias in the selected studies. Another limitation of this research work is based on the review of earlier studies conducted by different authors at a different time frame and locations as well as motivational factors. Hence, a generalization of results may be inaccurate.

Further studies aim to overcome some limitations, focusing on the student-teacher knowledge, attitude, and practice of environmental sustainability with unified standardized tools that make progress toward CP in developing countries, with important consequences in SWM.

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