# Architects' Perception of Acid Rain: The Need for Reprioritising Design Values in Studio Pedagogy

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***Abstract:*** **One of the major issues that constitute threat to the international peace, security and continued human existence is environmental degradation. Reports are presented annually about the increasing depletion and pollution of the natural environment by virtually all forms of developmental activities. Among the preponderant negative consequences of these activities is the issue of acid rain deposition, flooding and overheating. While literature is replete with the challenges some of these phenomena pose to architects, little or no attention has been given to the issue of acid rain which has been found to have deleterious effects on buildings. The aim of this paper, therefore, is to determine the level of awareness, perception and responses of architect to this challenge, using Lagos Metropolis as an empirical focus. Data were obtained through structured questionnaire administered on 157 randomly selected practicing architects in Lagos, Nigeria. Descriptive statistics were used to analyse the data. The results were further subjected to Linear Regression Analysis. The findings revealed high level of awareness of acid rain among the architects who also feel concerned about phenomenon. Their response to the adaptation and mitigation of the phenomenon was however, very low. The paper establishes architectural design values as one of the major contributors to this behaviour. It concludes by suggesting the need to update architectural education and theories to include climate responsive pedagogies in the learning process.**

***Keywords:*** **Acid rain, Adaptation, Architect, Awareness, Building, Design values, Perception.**

## I. INTRODUCTION

Man's quest for better living has led to promotion of more intensive and more advanced economic activities through such means as education, improved tools and techniques, more available financing, better transportation facilities and creation of new businesses. This is, however, not without a price. Almost all forms of modern day development effort trigger off tremendous environmental degradation in addition to the age long traditional practices. Developmental activities such as construction, transportation and manufacturing do not only deplete natural resources but also release harmful substances into the atmosphere with fatal consequences. One of these environmental problems is acid rain.

Acid rain is a broad term that is used to describe various ways through which acid falls from the atmosphere to the ground. It could be in form of rain, snow, sleet, fog, dew, hail, and cloud water (Mahadam & Mane, 2013). There are also dry depositions of acidifying particles and gases which can be transformed into salt and cause the same effects as wet deposits (Bhargava & Bhargava, 2013). It is formed when certain gases like sulphur dioxide ($SO_2$) and oxides of nitrogen ($NO_x$) react with water and other chemicals in the air. These gases are released into the atmosphere mainly through human activities. This is corroborated by Department of the Environment and Heritage (2005), which affirms that 99% of $SO_2$ and $NO_x$ in air come from burning fuels in electric utilities, motor vehicle and other industrial activities. The gases are produced through natural processes, too: nitrogen oxides are formed through the extreme heating of air when thunderstorm produces lightning, while sulphur gases are discharged from erupted volcanoes and rotting vegetation (Department of the Environment and Heritage, 2005; Signh & Agrawal, 2008).

This phenomenon has been found to have significant impacts on building structures and materials. Sensale *et al* (1998) reported that acid precipitations with high pH level of between 3.0 and 5.0 have great effect on calcareous stones such as marble, limestone and sandstones. According to them, the calcium carbonate in these stones reacts with sulphur present in dry deposition and form calcium sulphate as shown below:

$$CaCO_3 + H_2SO_4 + H_2O = CaSO_4.2H_2O + CO_2$$

This is soluble and the acids so formed are washed off from the surface when next it rains. Consequently, the structures, carvings and monuments made of these materials are damaged and their features are lost. They are also disfigured by the black crust that was formed. The incremental effects of carbonate erosion due to acid rain were quantified by Baedecker *et al.* (1992). Findings from this study suggested that approximately 30% of erosion by dissolution could be attributed to this phenomenon.

According to Signih and Agrawal (2008), the hydrogen ion in acid rain equally attacks the calcium hydroxide ($Ca(OH)_2$) in the hardened cement paste and further corroded by sulphate ion ($SO_4^{2}$) as shown below:

$$Ca(OH)_2 + H_2SO_4 = CaSO_4 + H_2O$$

This dissolution, which is accelerated by increase in the porosity of the cement paste, concentration of the acid, the solubility of the calcium salts of the acid and the fluid transport of the concrete, exposes the aggregates in the concrete structures, thus weakening it (Signih & Agrawal, 2008). In the similar manner, other building fabrics containing cement paste are weakened by acid rain: it attacks the mortar joint of bricks, stones and tiles, thus causing the brick and stone structure to crumble and the tiles to fall off. Hughes and Bargh (1982) and Mahadam and Mane (2013) also reported that acid rain dissolves the fabric that helps to hold together silica grains in the brick, resulting in the bricks becoming weak and fragile and this eventually causes brick walls to collapse. The gypsum formed on the surface of the concrete expands 1.5-2.2 times in volume. This creates tensile stress in the concrete, leading to crack and spall in the concrete structures (Zhang *et al*., 2019). It was reported that the cost of repairing and replacing concrete structures every year due to acid in the US in the 1950s was more than $5 billion. In the Britain, the economic loss due to acid rain was 0.15% of Gross National Product (Zhang *et al*., 2012).

The damaging effects of acid rain are not limited to destruction of calcareous stones and cement paste alone; it also increases corrosion rate of metals. Signih and Agrawal (2008) and Sorensen *et al.* (2009) assert that when iron comes in contact with acid rain, the acidic water produces additional proton that gives iron a positive charge:

$$4Fe(s) + 2O_2 + 8(aq) = 4Fe^{2+} + 4H_2O\ (l)$$

This metallic ion combines with more oxygen to form brown iron oxide (rust) as illustrated below:

$$4Fe^{2+} + (aq) + 4H_2O\ (l) = 2Fe_2O_3(s) + 8H^{-} + (aq)$$

As such, metallic structures or components like rooftop flashings, downspouts, nail and other exposed metals on roof are corroded, leading to reduction in strength and poor appearance (Berghage *et al*., 2007). The corrosion rate is even said to be two or ten times faster in polluted urban than in the rural areas (Tolba, 1983). Treasures like drawings, fabrics costumes are also eroded by wet and dry acid depositions. It particularly penetrates the primer of paint causing substrate corrosion and coating delamination (DeSoto Construction Coatings, 1981; Sorensen *et al*., 2009; United States Environmental Protection Agency (USEPA), 2008; Bhargava & Bhargava, 2013).

Perhaps, more disturbing is the report released by the scientists, in recent times, which indicates higher prevalence of the phenomenon. Carbon dioxide concentration which was reported to be 281 parts per million (ppm) in 1750 has increased to 368 ppm in 2006 representing 31% increase. The concentration of nitrogen oxides has equally been reported to be 17% more than it was during the preindustrial period (IPPC, 2007). Although acid deposition is common in the north-eastern United States, south-eastern Canada and much of Europe, other parts of the world are also in danger of being impacted by the phenomenon owing to wider dispersal of the acid deposition over vast distances by the prevailing winds (USEPA, 2008). Given the policies of many developing countries to achieve sustainable development goals comparable with the developed world, the potential for the formation of and damage from acid rain in these areas is very high. Adequate strategies that would minimize the impending catastrophe are therefore imperative. If architecture is understood as a responsive and problem-solving effort, then architects have a great role to play in this effort. While different directions have evolved and continued to evolve in the developed nations of Europe and America, little is known about the preparedness of architects in developing nations to take up this challenge. It is in light of this the present study was conceived.

## II. LITERATURE REVIEW AND THEORETICAL CONCEPTS

Concern for the preponderant negative consequences of environmental degradation has led to the emergence of the concept of sustainable development. This concept advocates for policies and actions that would allow for economic growth while at the same time minimising damages to the environment (World Commission on Environment and Development, 1987). It is generally accepted that for the world to achieve this goal, the wider public will need to engage themselves in practices and lifestyles that are environmentally friendly. This has generated wide interest among researchers, all exploring the means by which pro-environmental behaviours can be understood and facilitated. The pioneering works in this regard examined the relationship between environmental knowledge and pro-environmental behaviour basing their studies on rationalist models. These models assumed that educating people about environmental issues would automatically result in more pro-environmental behaviour (Burgess et al, 1998). Schultz (2002) hypothesized that a well-designed campaign strategy that incorporates knowledge on causes, consequences and solutions to environmental problems would change beliefs and increase knowledge which would consequently lead to behavioural change. This holds true particularly for an act or policy that has direct impact on people (Rajeek 1982 cited in Kollmuss & Agyeman, 2002).

However, scholars are increasingly pointing out that knowledge and awareness does not lead to pro-environmental behaviour in most cases. It was argued that environmental knowledge could only intensify beliefs people already have but is not generally effective in enacting extreme behavioural changes (Skyoles *et al*, 2005; Morgan, 2012; Hargreaves, *et al*, 2003). People's perception of environmental problems has also been found to be a significant predictor of environmental behaviour. For example, environmental problems such as climate change and acid rain are seen by many people as temporally and spatially distant phenomena. And because these environmental problems cannot be experienced directly, they tend to display little or no concern about the consequences despite their vast knowledge about the issues. Some researchers have demonstrated that even when people show great environmental concern, they may not attach much importance to either prevention or mitigation of such problems. Rather, they consider social issues such as poverty, terrorism, child trafficking, and drug trafficking as more important than finding solution to the challenges of acid rain or other environmental problems (van der Linden, 2014; Morgan, 2012). Corroborating this, Bohm (2003) contends that an individual that attaches great importance to environmental problems tends to be more worried about the consequences than an individual that sees the problem as less important than social issues even though he shows great concern for the phenomenon. This more active emotional state is, therefore, considered a stronger predictor of environmental behaviour.

Research has, however, shown that positive environmental attitude alone does not, at all times, translate to pro-environmental behaviour. Personality and situational factors have been identified as one of the factors that together influence behaviour as well. For example, in the studies conducted by Hinton (2010), Ogah *et al* (2014) and Kollmuss & Agyeman (2002) it was revealed that a number of socio-demographic factors such as sex, education, income level, family size etc. play a significant role in pro-environmental behaviour. This is corroborated by the studies conducted by Fliegenschnee & Schelakovsky (1998) and Lehmann (1999), which revealed that women have a less extensive environmental knowledge than men but they are more emotionally engaged, show more concern about environmental destruction and are more willing to change. Kollmuss & Agyeman (2002) also contends that individual with higher level of education have more extensive knowledge about environmental issues and thus have the tendency to be more environment-conscious than people with low level of education.

Although, all these factors (knowledge, attitude and personal characteristics) have a large part to play in encouraging more positive behaviour, little or no attention has been given to the possible influence of architectural design values on architect's response to environmental challenges such as acid rain. These values, which are said to have a great influence on architectural design decisions, are at times in conflict with one another, thus compelling architects to prioritize (Ukabi, 2015; Bole & Reed, 2011). As pointed out by Ukabi (2015), the choice of value that is given higher priority depends on the schools of architecture and individual architects. The understanding of impact of architectural design values on adaptation or mitigation behaviour of architects will, thus, help in prescribing appropriate strategies that can engender positive response behaviour of architects towards acid rain challenges.

## III. METHODOLOGY

The study used a cross-sectional approach to examine the influence of knowledge, affection and architectural design values on architect's response behaviour towards the effects of acid rain on buildings. Participants were drawn from the register of architectural firms in Nigeria (2013 edition) compiled by Architects' Registration Council of Nigeria. The names of architectural firms located in Lagos was extracted from this register and arranged in alphabetical order, which were serialised later to form the sampling frame. Questionnaires were administered on 157 architects randomly selected from the sampling frame, using a table of random numbers.

The questionnaire consisted of four sections: socio-demographics (age, gender, years of working experience, school of study); awareness of acid rain; affection; design value and response behaviour. Questionnaire items were developed based on critical statements derived from literature and private discussions with the professional colleagues. Both face and content validity of the instrument were ascertained by giving it to an expert.

Awareness of acid rain and its effects on the building was measured in terms of knowledge the respondent has about acid rain, its effects on building and the measures commonly used to mitigate these effects. Each correct answer was scored "1", while wrong answer was scored "0". Total score for each respondent was obtained by summing up the scores. Affection was measured in terms of the degree of emotionality each respondent attach to the challenges acid rain poses to buildings. Respondents were asked to indicate how much they worry about a list of acid rain impacts on building on a four-point scale (4 for "a great deal", 3 for "a fair amount", 2 for "just a little" and 1 for "not at all"). In order to measure the value architects attach to acid rain challenges, participants were asked to respond to a series of questions on the importance of environmental requirements over other design values on a five-point Likert scale; while the dependent variable – response behaviour of architects towards acid rain challenges – was measured by asking the respondents to indicate on a five-point scale (1= Never to 5 = Always) how often they use preventive measures against the impact of acid rain on buildings in their designs.

The population characteristics and Likert responses were analysed by employing descriptive statistics through the use of mean and standard deviation for continuous variables and frequency/ percentages for categorical variables. Linear regression analysis was used to identify the factors that explain architects' response behaviour towards acid rain challenges, using Statistical Package for Social Sciences (version 25).

## IV. RESULTS AND DISCUSSION

*Demographic characteristics of the respondents*

Table 1 shows the statistical analysis of the respondents based on their age, gender and working experience. From a total of 157 respondents, 15 were young adults, 131 were middle aged and 11 were old adult. About 10 % of the respondents had little working experience, while 90% had been working more than 5 years. Seven percent of the respondent even had more than 30 years' working experience. In respect of gender, male architects represent 76.4% and female 23.6%. Majority of the respondents were full members of architectural professional body (59.2%). About 15% belonged to the college of fellows of the professional body; while 16.6% and 14.6% of them belonged to associate and graduate membership categories respectively. Most of them had master's degree as the highest qualification. About 10% of them also had doctorate degree; while just 14% had bachelor degree and its equivalent as their highest educational qualification. With this diversity in academic and demographic background, the respondents could be said to represent various interests in the architecture profession which gives credibility to the data collected.

Table 1: Demographic Characteristics of the Respondents

| Categories | Attributes | Frequency | Percentage (%) |
|---|---|---|---|
| Age | Young Adult<br>Middle-Aged<br>Old Adult | 15<br>131<br>11 | 9.6<br>83.4<br>7.0 |
| Working Experience | 1-5<br>6-15<br>16-25<br>26-30<br>Above 30 | 15<br>56<br>60<br>15<br>11 | 9.6<br>35.7<br>38.1<br>9.6<br>7.0 |
| Gender | Male<br>Female | 120<br>37 | 76.4<br>23.6 |
| Educational Qualification | Ph.D<br>M.Sc.<br>B.Sc/HND | 15<br>120<br>22 | 9.5<br>76.4<br>14.1 |
| Membership Status | Fellow<br>Full Member<br>Associate Member<br>Graduate Member | 15<br>93<br>26<br>23 | 9.6<br>59.2<br>16.6<br>14.6 |

*Architects' Response to Acid Rain Challenges*

The response of the respondents to the challenges of acid rain is not encouraging enough. As can be seen in Table 2, the grand mean is below average. Out of 4 items that indicate positive design response, only one item had a mean score that is above 2.5. Just 12% of them always use stainless steel; while a little above 14% regularly used aluminium to encase concrete structures. This portends danger to the safety of building occupants, as well as the economy of the building owners and the country in general.

Table 2: Architects' Response to Acid Rain Challenges

| Design Responses | Frequency of practice | | | | | Mean |
|---|---|---|---|---|---|---|
| | Always | Very often | Quite often | Seldom | Never | |
| Encasing concrete structures with aluminium. | 22<br>(14.1) | 26<br>(16.5) | 11<br>(7.0) | 34<br>(21.6) | 64<br>(40.8) | 2.48 |
| Using limestone and marble as external wall finishes. | 41<br>(26.2) | 56<br>(35.7) | 15<br>(9.6) | 30<br>(19.1) | 15<br>(9.6) | 2.12 |
| Using paints for the external walls. | 64<br>(40.8) | 64<br>(40.8) | 26<br>(16.5) | 3<br>(2.0) | 0<br>(0) | 1.80 |
| Using stainless steel. | 19<br>(12.1) | 19<br>(12.1) | 7<br>(4.47) | 56<br>(35.7) | 56<br>(35.7) | 2.29 |
| Using aluminium as external cladding. | 11<br>(7.0) | 19<br>(12.1) | 11<br>(7.0) | 67<br>(42.7) | 49<br>(31.2) | 2.21 |
| Using deep roof overhang. | 45<br>(28.6) | 45<br>(28.6) | 22<br>(14.2) | 45<br>(28.6) | 0<br>(0) | 3.57 |
| Grand Mean | | | | | | 2.41 |

Note**:** Figures in parentheses are row percentages

*Respondents' awareness of acid rain*

The level of awareness of architects about acid rain is presented in Table 3. Majority of the respondents had good knowledge of acid rain, its formation, the challenges it poses and the appropriate design responses to the challenges. As postulated by some scholars such as Burgess et al *(*1998) and Schultz (2002), it is expected that a person that has vast knowledge about the impact and process for mitigating such impact would be able to apply the knowledge to avert the consequences. Surprisingly, the reverse is the case in this study. The great knowledge possessed by the respondents does not translate to responding positively to the menace. This finding is in line with the postulation of Skyoles *et al* (2005), Morgan (2012) and Hargreaves *et al* (2003) who argued that knowledge could only intensify existing beliefs but could not initiate change in behaviour with high intensity. The strategy to change the adaptation and mitigating behaviour of architects towards acid rain, thus, goes beyond the incorporation of knowledge in the campaign strategy.

Table 3: Level of Awareness of Acid Rain

| Knowledge | Yes | No |
|---|---|---|
| Acid rain can be in form of snow, rain, sleet, fog, hail and cloud water | 138<br>(88.0) | 19<br>(12.0) |
| Acid rain is formed when sulphur dioxide and oxides of nitrogen react with water and other chemicals in the air. | 149<br>(94.9) | 8<br>(5.1) |
| Acid rain can travel far | 127<br>(80.9) | 30<br>(19.1) |
| Acid rain weakens concrete structures | 157<br>(100) | 0<br>(0) |
| Acid rain attacks the mortar joints of bricks, stones and tiles | 153<br>(97.5) | 4<br>(2.5) |
| Limestone and marbles are dissolved by acid rain | 138<br>(88.0) | 19<br>(12.0) |
| Metallic components like rooftops, nails, sprouts are corroded by acid rain | 149<br>(94.9) | 8<br>(5.1) |
| Acid rain can cause delamination of paint | 157<br>(100) | 0<br>(0) |
| Effects of acid rain on buildings can be mitigated through the use of deep roof overhang | 131<br>(83.3) | 26<br>(16.7) |
| Impact of acid rain can be reduced by using stainless steel and aluminium | 123<br>(78.4) | 34<br>(21.6) |
| Mean Percentage | 90.6 | 9.4 |

Note: Figures in parentheses are row percentages

*Architects' Concern for Acid Rain*

Table 4 depicts the concern architects in the study area had for the challenges of acid rain. According to the table, majority of the respondents show great concern for the phenomenon. A large percentage of the respondents were concerned a great deal about virtually all the challenges acid rain poses to building structures. The mean score for each of the items was above the median score of 2. With all this great concern, the response to the situation is still very low. This is contrary to popular belief that people attach much importance to a phenomenon they feel concerned about. The concern for the consequences of acid rain in this study area is not commensurate with their design practice. One possible explanation for this indifference is that many of them could see acid rain as being a temporally and spatially distant phenomenon. And because this environmental problem cannot be experienced directly or immediately, they tend to ignore the consequences despite their vast knowledge and concern about the issue.

Table 4: Architects' Concern for Acid Rain

| Acid Rain Challenges | Level of Concern | | | | Mean |
|---|---|---|---|---|---|
| | A | B | C | D | |
| Weakening of concrete structures | 75 (47.8) | 45 (28.7) | 34 (21.6) | 3 (1.9) | 3.30 |
| Corrosion of metallic components of building | 89 (56.7) | 64 (40.8) | 4 (2.5) | 0 (0) | 3.50 |
| Delamination of paints by acid rain | 89 (56.7) | 49 (31.2) | 19 (12.1) | 0 (0) | 3.40 |
| Destruction of buildings made of limestone and marble | 56 (35.7) | 56 (35.7) | 37 (23.5) | 8 (5.1) | 3.01 |
| Failure and collapse of brick walls, stonewalls and tiles | 52 (33.1) | 49 (31.2) | 49 (31.2) | 7 (4.5) | 2.93 |
| Grand Mean | | | | | 3.22 |

Notes: 1. A=A great deal; B=A fair amount; C=Just a little; D=Not at all

2. Figures in parentheses are row percentages

*Design values of Architects*

The design values of the respondents were presented in Table 5. The result indicates that majority of them held the view that the issue of acid rain should be subservient to aesthetics and other social or architectonic concerns. They rationalise adaptation and mitigation of acid rain consequences with other design values. For example, 54.8% of the respondents agreed that the issue of acid rain should be placed on equal footing with cultural values. Only 28.7% disagreed on this. More than 80% of them also held that aesthetic consideration is as important as acid rain issue; while 74% agreed that the phenomenon should be made to take its rightful place next to gender-based values. All these design priorities could not make them to respond positively to acid rain challenges. It is evident from this finding that architectural design values constitute an important part of what influences architects when they make their design decisions.

Table 5: Architects' Design Values

| Statement | Level of Agreement | | | | | Mean |
|---|---|---|---|---|---|---|
| | SA | A | U | D | SD | |
| The issue of acid rain should be placed on an equal footing with cultural values. | 34 (21.7) | 52 (33.1) | 26 (16.6) | 41 (26.1) | 4 (2.5) | 2.55 |
| Architectural decisions on acid rain should take preference over economic matters | 34 (21.7) | 14 (8.9) | 19 (12.1) | 90 (57.3) | 0 (0) | 2.85 |
| Acid rain should be made to take its rightful place next to gender-based values. | 64 (42.8) | 49 (31.2) | 33 (21.0) | 11 (7.0) | 0 (0) | 1.94 |
| Aesthetic consideration is as important as the concern for acid rain. | 41 (26.2) | 86 (54.8) | 22 (14.0) | 8 (5.1) | 0 (0) | 1.92 |
| Solution to acid rain is more important than creating a novel or spectacular design. | 19 (12.1) | 52 (33.1) | 56 (35.7) | 30 (19.1) | 0 (0) | 3.38 |
| Combating acid rain challenges requires more attention than dealing with social issues in design. | 26 (16.6) | 4 (2.5) | 19 (12.1) | 41 (26.1) | 67 (42.8) | 2.24 |
| Grand Mean | | | | | | 2.48 |

Notes: 1. SA=Strongly Agree; A=Agree; U=Undecided; D=Disagree; SD= Strongly Disagree

2. Figures in parentheses are row percentages

Table 6: Regression Coefficients

| Predictors | Standardised Coefficients | *T* | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|
| | | | | Tolerance | VIF |
| Knowledge | -.726 | 1.085 | .139 | .259 | 3.860 |
| Emotion | -.907 | 1.054 | .147 | .662 | 1.511 |
| Design values | .595 | 1.767 | .000 | .277 | 3.608 |

$R^2$ = .612, P = 0.002, F (3,153) = 6.468

The regression analysis shown in Table 6 supports this finding. Out of the three factors examined, architectural design value was found to be the major contributing factor to architect design response to acid rain. While other factors: knowledge (β = -.726, P = .139) and emotion or concern (β = -.907, P = .147 have no significant relationship with architects' mitigating and adaptation behaviour towards acid rain challenges; architects' design values were found to be positively correlated (β = .595, P = 0.00). The model summary, which is significant at 95% confidence level (F(3,153)=6.468, P = 0.002), shows $R^2$ value of .612, implying that 61.2% variation in response behaviour is explained by these independent variables. This may not be unconnected with the form of architectural education received by the architects. Architectural design pedagogy has been criticised of "focusing more on form issues, while oversimplifying programmatic and other contextual issues within which buildings are created" (Salama, 2005). The intervention strategy towards improving the poor architects' response to acid rain phenomenon, therefore, lies, to certain extent, in its ability to make the architects to have a correct perception of acid rain.

## V. CONCLUSION

This research has examined the response of architects to acid rain challenges in Lagos Metropolis, Nigeria. It showed that the response was quite low, which according to the paper has negative implications for, not only the socioeconomic development of the country and individuals, but also for safety of the building occupants. It beamed its searchlight on the possible influence of knowledge, emotion and architectural design values on this behaviour. While architectural design value was found to be the main contributor to the mitigation and adaptation behaviour of architects towards the menace of acid rain; knowledge and emotion was found to be negatively correlated. This is contrary to the expectations of many scholars who believe that architects' knowledge and concern about the consequences of the phenomenon should be able to make the architects adopt design strategies that would minimise the production of acid rain or mitigate the effects of acid rain on buildings. The paper suggested that this could be due to temporally and spatially distant nature of the phenomenon; and that appropriate design strategies were not deployed by them probably because they are not directly affected. As established by the study, low response to the phenomenon by the architects could be explained by the architectural design values of the architects.

All this implies that awareness-raising campaign cannot be totally relied upon to engender positive response to acid rain challenges. Neither could architects be easily made to embrace design strategies that mitigate the effects of acid rain on building through attitudinal change alone. Instead, intervention strategy should be the one that has ability to make architects to reorder their design priorities. Since enduring architectural design values are imbibed by architect right from their training days, architectural education policy-makers have a big role play in this regard. Architectural curriculum should be redesigned and directed towards the provision of education that offers the students a broad based knowledge and values with particular emphasis on environmental issues pertaining to design. In essence, students should be actively engaged in design and scholarship that offers new insights into the role of architecture in environment. Tutorials and assessment of the studio assignments should focus on the elements of resilient design, attaching, at least, equal importance to these design parameters. Within this context, students can challenge the existing design values and offer innovative approaches that are germane to acid rain challenge facing the architectural profession and the whole world.

## REFERENCES


[1] Baedecker, P.A., Reddy, M.M., Riemann, K.J., & Sciammarella, C.A. (1992). Effects of acidic deposition on the erosion of carbonate stone: Experimental results from the United States National Acid Precipitation Assessment Programme. *Atmosphere and Environment, 263*, 147 – 158.

[2] Bhargava, S., & Bhargava, S. (2013). Ecological consequences of the acid rain. *IOSR Journal of Applied Chemistry, 5(4)*, 19 – 24.

[3] Bhatti, W., Streets, D.G., & Foell, W.K. (1992). Acid rain in Asia. *Environmental Management, 16*(4), 541-562.

[4] Blake, J. (1999). Overcoming the 'value–action gap' in environmental policy: Tensions between national policy and local experience. *Local Environment*, *4*(3), 257–278.

[5] Bohm, G. (2003). Emotional reactions to environmental risks: Consequentialists versus ethical evaluation. *Journal of Environmental Psychology*, *23*, 199-212.

[6] Bohm, G., and Pfister, H-R. (2001). Mental representation of global environmental risks. In G.

[7] Bohm, J. Nerb, T. McDaniels and H. Spada (Eds), *Environmental risks: Perception, evaluation and management* (pp. 1-30). NY: Elsevier Science/JAI Press.

[8] Bole, S., & Reed, R. (2011). The value of design: A discussion paper. *Architectural Science Review*, *52* (3). 169-175.

[9] Burgess, J., Harrison, C., & Filius, P. (1998). Environmental communication and the cultural politics of environmental citizenship. *Environment and Planning A*, (30), 1445–1460.

[10] Department of the Environment and Heritage (2005). Air quality sheet. Retrieved from: https://www.epa/gov/$SO_2$-pollution

[11] DeSoto Construction Coatings (1981). Dramatic proof of acisd rain protection. *Architectural Record*, March 3, 73.

[12] Encyclopedia.com (2018). The environment: A revolution in attitudes. Retrieved from http://www.encyclopedia.com

[13] Fliegenschnee, M. & Schelakovsky, M. (1998) *Umweltpsychologie und Umweltbildung: eine Einfu ̈hrung aus humano ̈kologischer Sicht* (Wien, Facultas Universita ̈ts Verlag)

[14] Hargreaves, I., Lewis, J., and Speers, T. (2003). Towards a better map: Science, the public and the media. ESRC, UK.

[15] Heimsath, H. (1977). *Behavioural architecture: Toward an accountable design process*. New York: McGraw-Hill

[16] Hines, J.M., Hungerford, H.R., & Tomera, A.N. (1986). Analysis and Synthesis of Research on Responsible Pro-Environmental Behavior: a Meta-Analysis. *The Journal of Environmental Education*, 18(2). 1– 8.

[17] Hughes, R.E., & Bargh, B.L. (1982). *The weathering of brick: Causes, assessment and measurement. A report of the Joint Agreement between the US Geological Survey and the Illinois State Geological Survey*. New York: US Geological Survey.

[18] Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, *8*(3), 239 - 259.

[19] Lee, T. (1976) Psychology and Environment, Essential Psychology Series, London: MethuenLehmann, J. (1999) *Befunde empirischer Forschung zu Umweltbildung und Umweltbewusstsein* (Opladen, Leske und Budrich)

[20] Lockton, D., Harrison, D. and Stanton, N.A. (2009). Design for sustainable behaviour: Investigating design methods for influencing behaviour. Paper presented at Sustainable Innovation 09: Towards a Low Carbon Innovation Revolution International Conference, Farnham Castle, UK. 26 - 27, October.

[21] Mahadam, P.D., & Mane, A.V. (2013). Effect of simulated acidic rain concentrations on selected materials used in construction. Environmental Science: An Indian Journal, 8(10), 396 – 406.

[22] Morgan, E. (2012). Does design affect behaviour? A case study of Pomona and Sontag Halls. B.Art Thesis, Department of Environmental Analysis, Pomona College, Claremont, California.

[23] Ogah, A.T., Alhassan, M.M., Sangari, D.U. and Magaji, J.I. (2014) 'The Influence of Households Size, Level of Education and Income on Waste Generation Rates in Mararraba Area of Karu Local Government Area, Nasarawa State, Nigeria'. J. of *Environmental Sciences and Resource Management*, 6(2):51 – 58.

[24] Oladokun, M.G., Motawa, I.A., and Banfill, P.F.G. (2012), 'Modelling techniques for capturing the socio-technical aspects of sustainability in post-occupancy stage of buildings'. In: *Proceedings of Retrofit 2012 Academic Conference*, University of Salford, Greater Manchester, United Kingdom, 24th – 26th January.

[25] Salama, A.M. (2005). A process oriented design pedagogy: KFUPM Somophore Studio. *CEBE Transactions*, *2*(2), 16 – 31.

[26] Schultz, P.W. (2002). Knowledge, information and household recycling: examining the knowledge deficit model of behaviour change. In: T. Dietz and P.C. Stern (eds). *New tools for environmental protection and voluntary measures.* New York: The National Academic Press.

[27] Sersale, R., Frigione, G., & Bonavita, L. (1998). Acid deposition and concrete attack: Main influence. *Cement and Research, 28*, 19 – 24.

[28] Sorensen, P.A., Kiil, S., Dan-Johansen, K.., & Weinell, C.E. (2009). Anti-Corrosive coatings: A review. *Journal of Coating Technology and Research*, *6*(2), 135-176.

[29] Tolba, M.F. (1983). Earth (Planets). In R. Lamb, P. Allen, & United Nations Environment Programme (eds.) *Earth Matters*. Nairobi, Kenya: United Nations Environment Programme

[30] United States Environmental Protection Agency (2008). *Learning about acid rain*. Washington, DC, US: United States Environmental Protection Agency

[31] Ukabi, E. (2015). Conserving the Architects' Jewel in the 21st century. *Architectural Research*, *5*(1), 10-15.

[32] van der Linden, S. (2014). Towards a new model for communicating climate change. In S. Cohen, J. Higham, P. Peters and S. Gossling (eds). *Understanding and governing sustainable tourism mobility: Psychological and behavioural approaches* (pp. 243-275). Routledge: Taylor and Francis Group.

[33] World Commission on Environment and Development (1987). *Our Future*. London: Oxford University Press.

[34] Wu, D.W. DiGiacono, A. & Kingstone, A. (2013). A Sustainable Building Promotes Pro- Environmental Behaviour: an Observational Study on Food Disposal', *PLoS ONE,* 8 (1)

[35] Zhang, Y., Gu, L., Li, W., & Zhang, Q. (2019). Effect of acid rain on economic loss of concrete structures in Hangzhou, China. International Journal of Low-Carbon Technologies, 14, 89 – 94.

[36] Zhang, Y., Fan, Y., & Li, H. (2012). Influence of simulated acid rain corrosion on the uniaxial tensile mechanical properties of concrete. International Journal of Corrosion, 1, 1 – 7.