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ORIGINAL PAPER

Effect of pH Condition and Different Solution on the Slake Durability of Granitic Rocks

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Abstract The slake durability (SD) of a rock is a vital engineering property relevant to its evaluation and estimation of its degradability due to mechanical and chemical breakdown. This study assesses the influence of pH of slaking fluid and different acidic solutions on slake durability of granitic rocks (fine-grained and porphyritic granite) by carrying out slake durability test (SDT) in acidic and basic conditions or environment. Petrographic analysis and basic laboratory tests such as porosity, water absorption capacity, density, and point load test, Schmidt rebound hammer were performed on the granitic rocks. The SDT was carried out in accordance with the standard procedure in distilled water and in different slaking fluids prepared by adding suitable amount of H_2SO_4 and HNO_3 (representing acidic solutions) and NaOH (representing alkaline solutions) to distilled water. The SD of the granitic rocks was evaluated up to 8 cycles in acidic and basic solutions with pH ranging from 2 to 12. The slake durability index (SDI) of the granitic rocks range from very high to extremely high under the different pH and two acidic solutions. The lowest SDI was obtained when the pH of the testing fluid is 2 (both in H_2SO_4 and HNO_3 solutions). However, as the pH of the slaking fluid > 2, the durability index of the granitic rocks becomes indistinct depending on the rock material properties rather than the slaking fluid pH. The SDI of the granitic rocks in H_2SO_4 solution is greater than in HNO_3 solution at pH = 2. The granitic rocks have very high to extremely high durability. However, the granitic rock with coarse texture, low strength, high water absorption capacity and porosity is quite more liable to degradation in different environments.

Keywords Granite · pH · Slake durability · Slaking fluid · Weathering

Abbreviations

MGQC	Migmatite gneiss-quartzite complex
PBC	Precambrian basement complex
PLT	Point load test
SD	Slake durability
SDI	Slake durability index
SDT	Slake durability test
SRH	Schmidt rebound hammer

1 Introduction

One of the main issues of using rocks or rock aggregates as a construction material is their likely vulnerability to weathering or degradation when exposed to

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different conditions. Weathering can alter the properties of a rock material or aggregate from its initial characteristics to soil-like properties. This deterioration as a result of chemical, physical or biological factors can impact the durability of rocks in the course of time (Blows et al. 2003). Latham et al. (1993) defined rock durability "as the ability of a rock to maintain its physical and mechanical properties for a required period with respect to the set engineering applicability requirements such as its impact on the structure or its value as a building material". Thus, the evaluation of durability of rocks under different environmental settings or conditions is an important task in civil, mining, geotechnical and environmental applications. This will not only ensure the reliability of the structure constructed on or with the rock but also ensures its sustainability and safety.

In places where there is air pollution and areas constantly experiencing alternating wetting and drying (Yavuz 2006), weathering and degradation of rocks are quite extensive. The rate of degradation and weathering depends on properties of the rock materials/rock mass (Zorlu 2008), climatic factors (White and Blum 1995) and pH of rainfall (Huang et al. 2013). Salt weathering and acid rainfall are important environmental weathering processes or factors with a destructive effect on rocks as well as engineering constructions and monuments (Bell 2007; Pinho et al. 2017). The rapid development of industrial technology and extensive use of fossil fuel in most urban centers/cities have led to increase in greenhouse gases (such as CO, SO_2, NO_x, and CO_2) emission which may likely lead to the formation of acid rain. The produced acidic solutions (nitric or sulfuric acid solutions), and changes in pH value of the rain are believed to induced disintegration/degradation of rock through acid rain—rock interaction (Acker and Bricker 1992; Zhang and McSaveney 2018). Consequently, understanding the role of pH and different environmental conditions on the durability or disintegration of rock/rock aggregate and building stones has now become important (Erguler and Shakoor 2009; Fereidooni and Ghobadi 2015; Arman et al. 2019).

Resistance of rocks against weathering, and the durability and water sensitivity of rocks with respect to engineering applicability requirements are commonly evaluated by slake durability test (SDT) (ASTM D4644_08 2008). However, despite its acceptance, standardization by the ISRM and ASTM, and successful application in the study of rock resistance to weathering and durability, previous authors such as (Qi et al. 2015; Fereidooni and Khajevand 2019) have highlighted some of the limitations of this test. Slake durability, according to Gupta and Ahmed (2007), represents "the degradability of rocks due to the process of physical and chemical breakdown as in exfoliation, oxidation, solution, hydration, and abrasion". Recently, series of experimental investigations have been conducted to understand influence of pH on slake durability and varying environmental conditions on durability of different types of rock such as marble, limestone, shale, travertine, sandstone, and granite (Gupta and Ahmed 2007; Ghobadi and Mousavi 2014; Fereidooni and Ghobadi 2015; Arman et al. 2021a, b; Arman 2021). The result of the aforementioned studies revealed that pH of testing fluids, mineral composition of the rocks along with their texture, and properties such as porosity are related to slake durability of rocks (Gupta and Ahmed 2007; Khajevand and Fereidooni 2022).

Some of these studies also found a strong correlation between slake durability index (at different slaking cycles) and engineering properties of rocks such as porosity, unit weight, point load strength and Schmidt rebound hammer (Fereidooni and Khajevand 2017; Khajevand and Fereidooni 2022). There are, however, relatively few studies in literature on the effect of slaking fluid pH level (i.e. acidic and alkaline) to simulate the influence of diverse geo-environmental conditions on durability of granitic rocks. Kim and Park (2003) studied the effects of acid solution on the weathering of granites from Seoul area and observed a reduction in durability of the granitic rocks following the acid weathering. However, the slake durability index of the granites is less than 1%. Gupta and Ahmed (2007) showed that rocks rich in calcium and magnesium carbonate are adversely affected in acid environment, whereas rocks rich in quartz, feldspar, and muscovite are independent of pH of slaking fluid, there is need for further research in other to validate this proof. This is because, Schiavon (2007) investigated the 'kaolinization of granite in urban settings' and observed that SO_2 (from the air pollution) is responsible for rapid kaolinization of feldspars. He further stated that the kaolinization reaction leads to the decay of the rock when used as building stone because of the weaking of the rock microfabric. In

addition, Ghobadi and Momeni (2011) assessed the slake durability of granites using H_2SO_4 (with pH 2.5, 4, and 5.5) as slaking fluid. The authors revealed that the durability of the granitic rocks decreased as the pH of the slaking fluid reduces.

Precambrian basement complex (PBC) rocks are prevalent in Ado-Ekiti, Southwestern, Nigeria. These crystalline rocks include different rock types and vary in their mineralogy, petrographic and textural characteristics. An increasing use of these PBC rocks (especially the granites) as construction materials point to their importance as an engineering resource. These rocks are used for construction purposes such as building stones, foundations, pavement and facade stones, rock aggregates and filling with little or no information related their degradation mechanism and weathering potential in different environmental conditions. In this study, we discuss the influence of different environmental conditions (watery environment) on the degradability and durability of porphyritic and fine-grained granites from Ado-Ekiti SW, Nigeria. To achieve this purpose, we examined the petrographic and physical properties of these granitic rocks. Then, the SDT was performed using solutions of different pHs. The acid solutions were prepared using H_2SO_4 and HNO_3 while the basic solutions were prepared using NaOH.

2 Study Area

The study area, Ado-Ekiti, falls within latitude 7° 34′ and 7° 44′ N and longitude 5° 11′ and 5° 18′ E. Ado-Ekiti is situated in a tropical climatic zone. It has a well-defined rainy and dry season. Availability of moisture and high temperature characteristic of the area favor chemical weathering. Ado-Ekiti is one of the areas underlain by the PBC rocks of southwestern Nigeria. The rocks that make up the PBC are grouped into "the migmatite gneiss-quartzite complex (MGQC)", "the Schist Belts" and "the Pan-African Granites" (Elueze 2000). Among these groups, the MGQC is the oldest. The MGQC is intruded by charnockite, older granite, aplite, and quartz veins. Almost all the rock units that made up the PBC of southwestern Nigeria, except schistose rocks, are found in Ado-Ekiti. These rocks include granite gneiss, migmatite gneiss, granite and charnokite. Migmatite gneiss outcrop as highly denudated hills and are fine-grained in texture consisting of alternating bands of dark- and light-colored minerals. Quartzites are non-foliated and occur as ridges. The major mineral component in the quartzite is quartz with little amount of feldspar. The granites do not show any preferred orientation of constituent minerals. Their texture varies between fine-grained to porphyritic. In addition, the granites have compact interlocking crystals. The charnockite is dark grey in color and their texture varies from medium-grained to coarse-grained. The charnockite is found along the edges of the granites. The petrographic characteristics of these rocks can be found in the work of Afolagboye et al. (2016).

3 Material and Methods

In this study, rock samples were taken from two different varieties of granite: fine-grained and porphyritic granite. The porphyritic granite and fine-grained granite samples were taken, respectively, from a quarry site and their respective outcrops. The block (400*400*600 mm) samples taken were inspected to ensure they were fresh, not weathered and free of macroscopic defects or fractures. The properties (mineralogical and physical) of the rock samples were determined using appropriate standard testing procedures. The mineralogical properties of the rocks were examined by preparing thin sections. The prepared thin sections were studied under a polarizing microscope and the images analyzed. The point counting method was used to obtain the modal composition. The petrographic analysis was done in accordance with the standard specified by ISRM (1978). The physical properties of the granitic rocks such as water absorption capacity, water content, porosity, density and, Schmidt rebound hammer (SRH) test were determined using the ISRM (2007) suggested methods. N-type Schmidt hammer (impact energy of 2.207 Nm) was used to conduct the test. The point load test (PLT) was carried out according to the procedure recommended by the ISRM (1985). The PLT test was carried out at least three times and the average values recorded.

The durability or susceptibility to weathering of the granitic rocks as affected by different geo-environmental conditions or chemical environment was investigated by slake durability test (SDT). According to the procedure suggested by Franklin

and Chandra (1972), the durability of a rock is usually assessed using the 2nd Slake Durability Index (SDI). Gupta and Ahmed (2007) and Ghobadi and Momeni (2011), however, stated that two cycles SDT may not be adequate to indicate the durability of a rock. Taking this into consideration, the SDT in this study was performed in eight cycles. The number cycles used for the test was based on the work of Momeni et al. (2017) which states that for evaluating the long term durability of granitoids, at least eight slake durability cycles should be considered. The granitic rocks were tested for SD using slaking fluids with pH = 2, 4, 6, 7, 8, 10, and 12. The fluids or the testing liquids were prepared by adding adequate amount of H_2SO_4 and HNO_3 (representing acidic solutions) and NaOH (representing alkaline solutions) to distilled water. Based on ASTM (2008) standard, ten representative rock pieces of the granitic rocks, each weighing about 40–60 g were prepared and their edges were made blunt using a hammer (Fig. 1). The rock pieces were air-dried and placed in the drum of slake durability test apparatus. The drum was submerged or immersed in the slaking fluid at 20 °C and rotated at a standard rate (i.e., 20 rev/min) for 10 min. The rock fragments retained in the drum were oven-dried at 110 °C for twenty-four hours, and subsequent cooled and mass determined. This process was repeated eight times (8 cycles). SDI is defined "as percentage ratio of final and initial dry mass of rocks" in the drum.

4 Results and Discussion

4.1 Petrographic Characteristics

Four samples (2 porphyritic granite; 2 fine-grained granite) from granitic batholiths were investigated petrographically for their mineralogical composition. They were prepared into thin-sections and observed on a polarizing microscope. Textural variations and mineralogical characteristics observed on the outcrops and in hand specimens also reflect in their petrographic features. The porphyritic granite contains quartz (12–18%), feldspars (microcline, 16–23%; orthoclase, 18–21%; plagioclase, 20–26%) altogether accounting for between 54 and 63% of the total mineralogical composition. Hornblende (6–9%), biotite (8–12%), and muscovite (1–2%) constitutes the minor mineral aggregates. Quartz crystals are irregular, vary in size and isolated with characteristic well define edges (Fig. 2a, b). Biotite occurs in form of large brown acicular crystals with high aspect ratios (Fig. 2a, b). Biotite occurs in clusters while in some places, they are separated from each other. However, all the minerals show random distribution. Microcline has a characteristic cross-hatched twinning and its color ranges from grey to light brown. Plagioclase appears subhedral and shows recognizable Carlsbad twinning with well-defined edges. Smaller grains of hornblende and quartz form the supporting minerals in an interlocking crystal structure. Orthoclase

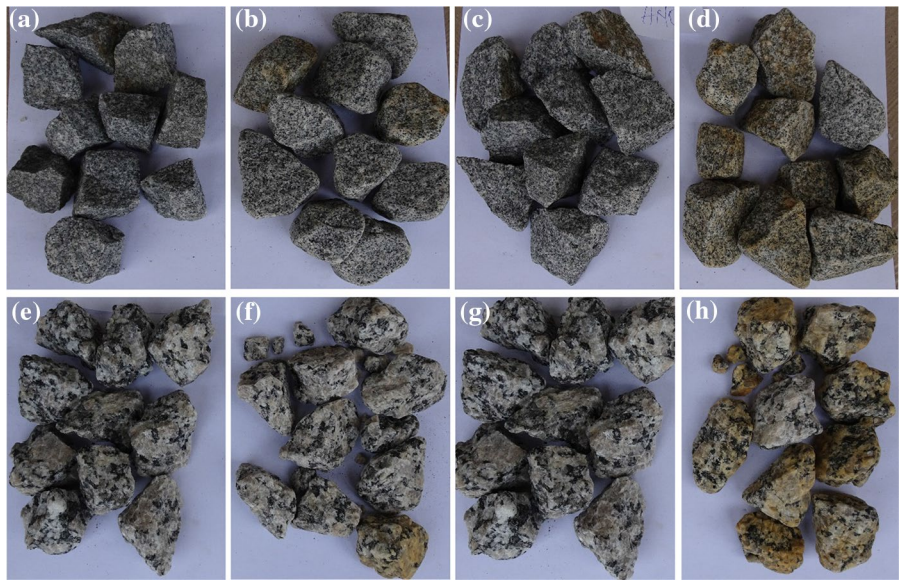


Fig. 1 Tested rock lumps before and after the slake durability test illustrating the variation in shape and size of the rock lumps after 8 cycles. **a** Fine-grained granite H_2SO_4 before cycling, **b** fine-grained granite H_2SO_4 cycle 15, **c** Fine-grained granite HNO_3 before cycling, **d** Fine-grained granite HNO_3 cycle 15, **e** porphyritic granite H_2SO_4 before cycling, **f** porphyritic granite H_2SO_4 cycle 15, **g** fine-grained granite HNO_3 before cycling, **h** fine-grained granite HNO_3 cycle 15. The pH of the acid solutions is 2

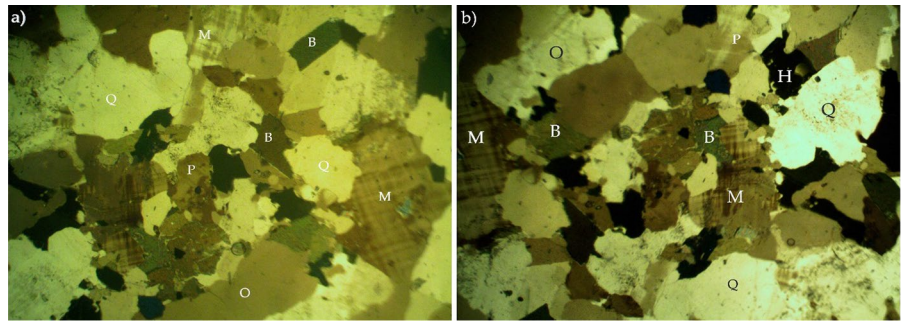


Fig. 2 Photomicrograph of porphyritic granite in transmitted light. Q, Quartz; P, Plagioclase Feldspar; O, Orthoclase Feldspar; M, Microcline; B, Biotite; H, Hornblende

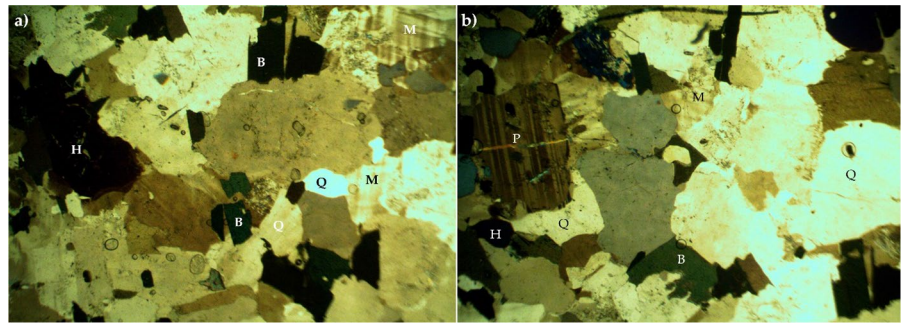


Fig. 3 Photomicrograph of fine-grained granite in transmitted light. Q, Quartz; P, Plagioclase Feldspar; O, Orthoclase Feldspar; M, Microcline; B, Biotite

crystals appear bulky and make contact with quartz and plagioclase. It has sutured edges and the crystals are striated.

The fine-grained granite comprises of quartz (40–46%), microcline (6–7%), plagioclase (8–10%), hornblende (32–35%) and biotite (10–15%). Biotite grains are randomly arranged, it has low relief and haphazard in orientation. They are dark to brown in color and located in interstices of other minerals (Fig. 3a, b). Few biotite crystals are in the form of acicular grains. Microcline appears as large, bulky grains with pronounced grid twins. Quartz is made up of fine, clear, and angular crystals. They also have sharp contacts. Hornblende is few, scattered and dark to straw green in color (Fig. 3a, b).

4.2 Physical and Index Properties

Texture and the constituent minerals are factors that affect the physical properties of intact rocks. Table 1 presents the physical and index properties of the granitic rocks. The average water content, water absorption capacity and porosity of the fine-grained granite is lower compared to those of porphyritic granite. The low water absorption capacity of the rocks may be due to low degree of weathering of the ferromagnesian and feldspathic minerals in the rock samples. The average values of porosity obtained for the fine-grained and porphyritic granites, respectively, are 0·34 and 0·52%. These values can be classified as very low according to the International Association for Engineering Geology and the Environment (IAEG 1979). The very low porosity of the tested granitic rocks may be due to their tight interlocking crystalline texture.

Table 1 Physical and index properties of the granitic rocks

Properties	FGG	PG
Water Content (%)	0.078	0.37
Porosity (%)	0.34	0.52
Density (g/cm^3)	2.57	2.61
Water Absorption Capacity (%)	0.46	0.71
Point Load Strength (MPa)	14.76	9.02
Schmidt rebound hammer	52	50.4

FGG, Fine-grained granite; PG, Porphyritic granite. The values presented in the table are the average of seven granitic rock specimens. In determining the Schmidt rebound hammer value the ten least values were discarded and the average of the highest ten values was calculated

The average dry density of the porphyritic granite (2.61 g/cm^3) is higher compared to the average dry density of the fine-grained granite (2.51 g/cm^3). The absence of voids and low moisture contents may be responsible for the high dry density of the tested granitic rock samples. Among the index tests, the point load and SRH tests are inexpensive methods for rock strength estimation. The point load strength and SRH value of fine-grained granite are higher compared to those of porphyritic granite. This indicates that fine grained granite is better that the porphyritic granite in term compressive strength. Afolagboye (2021) established good strong linear relationships between the unconfined compressive strength and point load strength of the granitic rocks.

4.3 Slake Durability Index (SDI)

The prepared rock lumps before the slaking test and after 8th cycle in selected different pH conditions are shown in Fig. 1. Little or no significant difference was observed in the shape or size of the fine-grained granite rock lumps after the 8th cycle of the SDT (Fig. 1a–d). The variation in size and shape in porphyritic granite is quite significant (Fig. 1e–h). The SDI of the granitic rocks in different pH is shown in Table 2. The SDI against the number of slaking cycles in distilled water (pH 7) for the granitic rock samples is shown in Fig. 4. The slake durability indices of the granitic rocks decreased as number of slaking cycles increases. The fine-grained granite samples, however, possesses higher slake durability index in all the cycles. This may be attributed to the difference

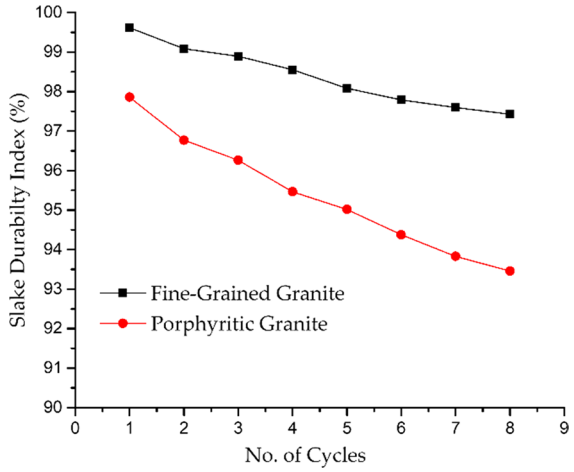


Fig. 4 Slake durability of granitic rocks tested in distilled water (pH 7)

Table 2 Slake Durability Indices of the Granitic rocks

Rock type	# Cycle	H_2SO_4			HNO_3			DW		NaOH	
		pH2	pH4	pH6	pH2	pH4	pH6	pH7	pH8	pH10	pH12
FGG	1	99.150	99.320	99.561	98.847	99.582	99.724	99.617	99.695	99.324	99.336
	2	98.806	99.000	99.084	97.656	98.180	98.993	99.085	99.302	98.886	98.984
	3	98.381	98.581	98.798	97.014	98.117	98.973	98.894	98.909	98.488	98.797
	4	97.936	98.241	98.302	96.447	98.054	98.776	98.553	98.298	98.110	98.590
	5	97.572	97.981	98.035	95.936	97.699	98.341	98.085	98.080	97.951	98.424
	6	97.390	97.861	97.940	95.445	97.699	98.144	97.787	97.906	97.772	98.341
	7	97.248	97.781	97.864	95.275	97.636	97.946	97.596	97.775	97.692	98.279
	8	97.167	97.721	97.826	95.143	97.594	97.828	97.426	97.666	97.612	98.279
PG	1	97.742	97.576	98.127	97.013	98.535	98.883	97.859	97.619	98.392	97.766
	2	96.869	96.884	97.297	95.854	97.134	97.523	96.769	97.317	96.985	97.028
	3	95.863	96.354	96.042	94.537	96.815	97.225	96.262	96.958	96.101	96.188
	4	95.161	95.356	95.232	93.732	96.306	96.723	95.464	96.524	95.477	95.573
	5	94.269	94.644	94.614	93.044	95.839	96.201	95.017	95.844	94.975	95.142
	6	93.852	94.033	94.247	92.101	95.393	95.717	94.374	95.390	94.472	94.630
	7	93.397	93.585	93.958	91.374	95.117	95.400	93.829	95.201	94.050	94.261
	8	92.998	93.116	93.649	90.804	94.968	95.196	93.459	94.540	93.668	94.036

FGG, Fine-grained granite; PG, Porphyritic granite; DW, Distilled water

in texture, and porosity of the rocks. The quartz contents and grain size are important geological factors controlling the durability and abrasion resistance of rocks.

To study the effect of acidic solutions on slake durability of the fine-grained granite and porphyritic granite, slake durability test was also performed using sulfuric and nitric acidic solutions with pH = 2, 4, and 6. The effect of number of slaking cycles on the durability of the granitic rocks in H_2SO_4 solution of different pH is shown in Fig. 5.

Similar to SDI of the granitic rocks when the pH of the slaking fluid is 7, the slake durability of the rock samples in acidic solution (H_2SO_4 solution) decreased as the number of cycles increases. In addition, the granitic rock samples with lower strength and higher porosity are quite susceptible to the acidic solution. Hence, the fine-grained granite possesses higher SDI at all the cycles and pH of the solution. Generally, as the pH of the solution decreases, the SDI decreased (Fig. 5). It was observed that all the granitic rocks have the lowest SDI when the pH of acidic solution was 2 (except in porphyritic granite at the first and second cycles). This may be attributed to the fact that the granitic rocks might be highly attack by the acidic agent at this pH. Although the slake durability indices of granitic rock samples tested at pH = 2 were the lowest, it should be noted that the influence of pH on the slake durability index is indistinct as the pH increases from 4 to 7 in some of the slaking cycles (Fig. 5). This is indistinct behavior is more pronounced in porphyritic granite samples. For instance, the 15th slake durability indices for porphyritic granite at pH = 2, 4, 6, and 7 were 92.998%, 93.116%, 93.649%, and 93.459% respectively. In fine-grained granite, the durability of the rock samples (8th slake cycle) at pH = 7 were less than the SDI of the samples at pH = 4 and 6.

The effect of number of slaking cycles on the SD of the granitic rock samples in HNO_3 solution of varying pH is shown in Fig. 6. Similarly, the slake durability of the granitic rocks in HNO_3 solution decreased as the number of cycles increases. The fine-grained granite also possesses higher SDI at all the cycles and pH of the HNO_3 solution.

As observed with H_2SO_4 solution, the SDI of the rocks decreased as the pH of the HNO_3 solution decreases (Fig. 6). In addition, the slake durability indices of the rock samples also recorded the lowest values at pH = 2 at all the slaking cycles. Similarly, the influence of pH on the slake durability index is indistinct as the pH increases from 4 to 7 in some of the slaking cycles (Fig. 6). This is indistinct behavior is prominent in fine-grained granite samples. In porphyritic granite, the slake durability indices of the granitic rocks at pH = 7, at all the slaking cycles, were less than the SDI of the samples at pH = 4 and 6.

The indistinct nature of the SDI in both acidic solutions as pH increased from 4 to 6 may be that the durability is probably related to the rock characteristics such as presence of micro-fissures, texture, and porosity rather than the pH of the slaking fluid

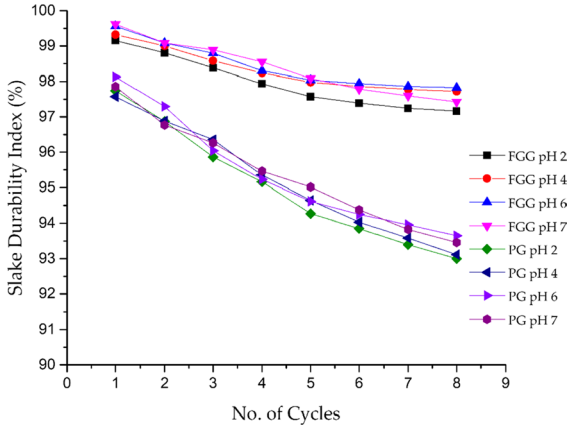


Fig. 5 Slake durability of granitic rocks tested in H_2SO_4 solution of different pH. FGG, Fine-grained granite; PG, Porphyritic granite

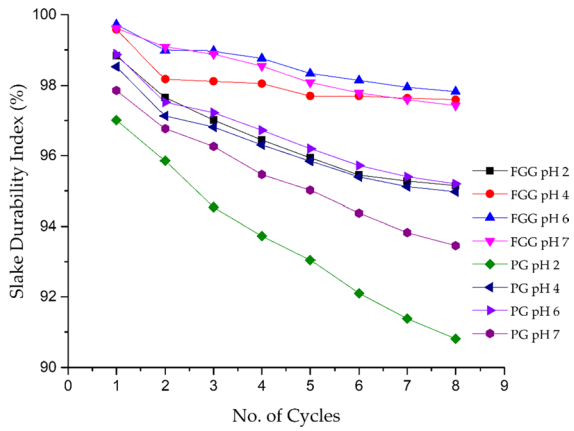


Fig. 6 Slake durability of granitic rocks tested in HNO_3 solution of different pH. FGG, Fine-grained granite; PG, Porphyritic granite

(Ghobadi and Momeni 2011; Yagiz 2018). This indistinct behavior in slake durability index as the pH increases from acidic to neutral pH was also observed in rocks like hornfels, carbonate rocks and sandstone.

Comparing the slake durability of the granitic rocks in the two acidic solutions (Table 2), it was observed that the SDI of the granitic rocks in H_2SO_4 solution is greater than in HNO_3 solution at pH = 2 (in all the slaking cycles). The aforementioned is also observed in fine-grained granite samples at pH = 4 (in all the slaking cycles). The SDI of the granitic rocks in HNO_3 solution is greater than in H_2SO_4 solution at other pHs except in few the slaking cycles. The result obtained in this study when the slake durability of the granitic rocks in H_2SO_4 solution is compared with that of HNO_3 solution at pH = 2 is different from the results reported by Jamshidi et al. (2009) cited in (Ghobadi and Momeni 2011) which states that "sulfuric acid compared with nitric acid possessing an equal pH has higher dissolution effects".

The effect of number of slaking cycles on the durability of the granitic rock samples in NaOH solution (alkaline solution) of different pH is shown in Fig. 7.

The slake durability of the rock samples in alkaline solution decreased as the number of cycles increases. The fine-grained granite samples have higher SDI in all the cycles and pHs. Close examination of Fig. 7 shows that no consistent pattern exists between SDI and the pH of the testing alkaline solution, although at slaking cycles 6, 7, and 8 the SDI of the granitic rocks is higher compared with the SDI of the rocks when the pH of the testing solution is 7. Compared with the SDI of the samples in acidic solutions, it is observed that the lowest durability index was obtained when the pH of the test fluid is 2 (both in H_2SO_4 and HNO_3 solutions). In addition, as the pH of the slaking liquid is > 2, the durability index of the granitic rocks can different and with no consistent pattern depending on the rock material properties rather than the slaking fluid pH. For instance, the durability index of fine-grained granite at pH = 10 is less than the durability index of the rock when the pH = 6 (both in H_2SO_4 and HNO_3 solutions) at all slaking cycles.

Compared with the durability classification provided by Franklin and Chandra (1972) the results show that both fine-grained and porphyritic granites have very high to extremely high durability. The range of SD of the granitic rocks based on pH of slaking fluid at the 2nd, 4th, 6th, and 8th cycles of slaking is shown in Table 3. At all the pH of the slaking liquids, the durability index of fine-grained granite is extremely high.

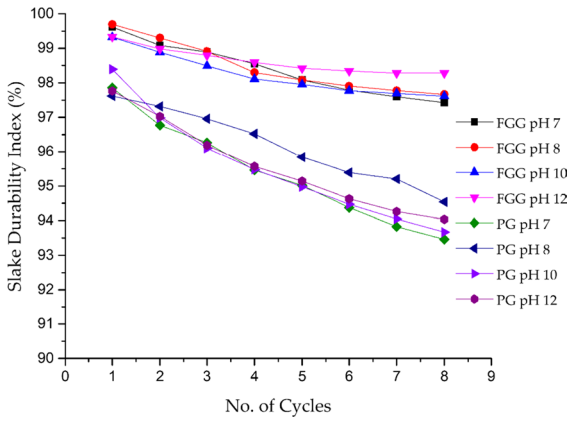


Fig. 7 Slake durability of granitic rocks tested in NaOH solution of different pH. FGG, Fine-grained granite; PG, Porphyritic granite

Table 3 Durability index of the fine-grained and porphyritic granites based on pH of slaking fluid at the different cycles of slaking

Rock type	# Cycle	H_2SO_4			HNO_3			DW		NaOH	
		pH2	pH4	pH6	pH2	pH4	pH6	pH7	pH8	pH10	pH12
FGG	2	1	1	1	1	1	1	1	1	1	1
	4	1	1	1	1	1	1	1	1	1	1
	6	1	1	1	1	1	1	1	1	1	1
	8	1	1	1	1	1	1	1	1	1	1
PG	2	1	1	1	1	1	1	1	1	1	1
	4	1	1	1	1	1	1	1	1	1	1
	6	2	2	2	2	1	1	2	1	2	2
	8	2	2	2	2	2	1	2	2	2	2

1, 95–100 (extremely high); 2, 90–95 (very high); FGG, Fine-grained granite; PG, Porphyritic granite; DW, Distilled water

5 Conclusions

SDT with eight cycles was carried on granitic rocks under different pH conditions and acidic solutions to study the effects of pH of slaking fluid and different acidic solutions on the durability of the rocks. Petrologically, the granitic rocks are not significantly different from each other in terms of observed mineral constituent but differ in term of texture. The average water content, porosity, and water absorption of the fine-grained granite is lower compared to those of porphyritic granite. The PLS and SRH value of fine-grained granite are higher compared to those of porphyritic granite. The SDI of the granitic rocks range from very high to extremely high under the different pH and acidic solutions. No definite pattern exists between the SDI and the pH of slaking liquid after the pH = 2. The lowest durability index was obtained when the pH of the testing fluid is 2 (both in H_2SO_4 and HNO_3 solutions), however, as the pH of the slaking liquid is > 2, the durability index of the granitic rocks becomes indistinct depending on the rock material properties rather than the slaking fluid pH. The SDI of the granitic rocks in H_2SO_4 solution is greater than in HNO_3 solution at pH = 2 while the durability in HNO_3 solution is greater than in H_2SO_4 solution at other pHs. The granitic rock with coarse texture, high porosity and low strength is relatively more susceptible to degradation in different environment. Hence, fine-grained granite is less susceptible to degradation in comparison with porphyritic granite. It has, however, been anticipated that the weight loss of specimens during the slake durability test is as a result of collisions between the rock specimens and surface of the drum rather than leaching, saturation, and chemical process which natural rocks or rocks used in structures such as monuments, dams and foundations are subjected to during the process of chemical weathering. We intend to further study the durability of these granitic rocks using accelerated weathering test. The test will be performed on standard prepared granitic rock core samples subjected to 8–10 cycles in solutions of different pH.

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Data availability Virtually all the Data are included in the article.

Declarations

Conflict of interest There are no conflicts of interest with regard to this manuscript.

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