In quest of green practices in manufacturing industries through literature review

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Abstract

Purpose – In order to improve environmental performance, manufacturing companies around the world have started to seek green practices (GPs) to adopt in their operations. Environmental awareness of the stakeholders has put the pressure and changed the focus of manufacturers. The purpose of this article is to gather GPs used in manufacturing industries through a literature review. It also aims at exploring other elements related to GPs in manufacturing firms.

Design/methodology/approach – The paper is exploratory in its approach. After searching relevant research articles from the online database, a review of 103 research articles has been conducted in the area of GPs in manufacturing industries.

Findings – This work attempts to offer a comprehensive list of GPs by studying the detailed relevant literature. This paper concludes that the concern of the use of GPs within manufacturing organisations is rising fast around the world, and research in this area is of great interest throughout the world over the last decade.

Research limitations/implications – This study has reported several earlier studies by searching the online database through some selected keywords only, but it has not performed a subjective overview for screening and choosing the research articles. This paper explores and gives a concise description of the GPs in manufacturing that will be helpful for further studies of green manufacturing (GM).

Originality/value – This study provides a comprehensive literature review of GPs in manufacturing industries. This review should give benefits to other scholars and practitioners interested in studying GPs related to manufacturing industries. It might represent new opportunities for relevant research that would contribute to more knowledge of GM being gained.

Keywords Green practices, Manufacturing industry, Green manufacturing, Sustainable production, Literature review

Paper type General review

1. Introduction

For sustainable development of any country, manufacturing is a very important element as it makes the required items to cater to the needs of society. The primary inputs for manufacturing of any item are material, energy and other resources of the industries. These inputs are transformed into desired products through manufacturing processes. Thus, manufacturing systems make boundless wealth to mankind but also consume a great number of resources and discard a lot of waste resulting in pollution in the environment (Liu *et al.*, 2002). This universal concern of the society about environmental pollution and depletion of natural resources is being reflected in many business activities of the manufacturing industries. Energy, materials and other natural resources are basic inputs for any manufacturing activity (O'brien, 2002). Over the last one decade, those ideas that focussed on environmental care have risen and recognised a common global obligatory to respond to issues that arise from a global change in climate and consumption of natural resources (Bigliardi and Bottani, 2012). So, to reduce environmental pollution by manufacturing, we need a strategy which will reduce the pressure of environmental pollution. Green manufacturing (GM) is a strategy to reduce an environment-polluting waste created during manufacturing activity by various measures. Fast growth in the manufacturing sector has also formed many other economic, social and environmental problems that are global warming and waste

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disposal (Sangwan, 2011). Some authors have also discussed other frameworks like sustainable production (SP), environmentally conscious manufacturing (ECM), clean manufacturing (CM), sustainable manufacturing (SM), environmentally benign manufacturing (EBM), environmentally responsible manufacturing (ERM) and clean production (CP), which are very similar to GM (Sangwan and Mittal, 2015). In this article, "green practices in manufacturing" are used to specify all the practices used in the abovesaid manufacturing framework.

Green practices (GPs) are defined as a set of techniques that control or reduce the possible negative effects of production, consumption of products and services on the physical environment, thus improving a firm's environmental performance (Rao, 2004). GPs in manufacturing activities revolve about using green energy, designing and developing green products and using green methods during manufacturing operations. In recent years, processes of manufacturing consider green issues due to social as well as environmental pressures. Recent studies have mentioned that in the next couple of decades, most manufacturers will have to face environmental issues in Asia (Govindan *et al.*, 2014). For GM, manufacturers implement such types of practices and techniques that consume less energy and material, reduce potentially harmful wastes through reuse and recycling and prevent pollution at the source itself (Inman and Green, 2018).

Awareness and regulations related to the environmental problem have put the pressure on manufacturers to produce the items and dispose of the industrial wastes in an environmentally friendly and answerable manner (Ilgin and Gupta, 2010). Non-appearance of GPs, manufacturing activities will steer towards making of a huge amount of wastes, misuse of natural resources and overconsumption of energy (Abdul-Rashid *et al.*, 2017). The very purpose of the present article is to give an overview of the literature on the GPs in manufacturing industries and to identify the GPs that can be adopted by manufacturing industries to enhance their environmental performance. Total 103 relevant refereed research articles are surveyed and analysed in this research paper.

2. Methodology

An extensive literature review was conducted through a search of relevant research papers on GPs. These online published research papers in the English language were searched at Google Scholar (GS) and Scopus online database. For searching the relevant academic research papers, search words having different combinations of "green practices" and "green practices in manufacturing", "sustainable practices", "environment conscious practices", "cleaner practices" and "green design", etc. have been used. Furthermore, websites of specific journals were also utilised to find relevant research papers. For finding and analysing the literature, Harzing's publish or perish (PoP) software is also employed, which is freely available for Windows and Linux platforms from Professor Anne Wil Harzing's very well-designed, content-rich website at: www.harzing.com/pop.htm (Jacsó, 2009).

Using PoP software, a full-query report from GS and Scopus database was saved. Many papers appeared in the list of full-query report. Then, going through the titles of the articles in the full-query report, most relevant research articles were shortlisted. For enhancing the research reliability, online databanks and journals and the individual papers were also verified. Electronic databases included Elsevier (sciencedirect.com), Emerald (emeraldinsight.com), Taylor and Francis (T&F) (tandfonline.com), IEEE (ieeexplore.iee.org), Springer (springerlink.com), Wiley (onlinelibrary.wiley.com) and Inderscience (inderscience.com). Taking the stated delimitations into account, going through the titles of the publications and eliminating the non-relevant papers from the list, finally the most

relevant research papers had been shortlisted. In total, two important research questions that guide this review of the literature are

RQ1. What are significant GPs which can be adopted in manufacturing industries?

RQ2. What is the status of research trends in GPs in manufacturing operations?

3. Literature review

3.1 Defining green practices in manufacturing

"Green" may be defined as an adjective which is concerned with environmentalism and which tends to preserve environmental quality. "Green" term may also be used as a verb which refers to the process of reducing the impact of the manufacturing process on the natural environment (Dornfeld *et al.*, 2013). So, GPs are environmentally conscious practices or environmental management practices (EMPs). EMPs are those techniques, policies and procedures which are used by firms that are specifically aimed at monitoring and controlling the impact of its operations on the natural environment (Montabon *et al.*, 2007). GPs are defined as activities or strategies applied by the organisation to lessen the negative environmental impacts (Awaysheh and Klassen, 2010; Dorantes *et al.*, 2018).

GPs are used for SM. The "sustainability" concept was first introduced in 1987 (Brundtland *et al.*, 1987), and the term "sustainability" is defined as rising the perspective of corporate to the consideration of environmental, economic and social features (Muñoz-Villamizar *et al.*, 2018). From the perspective of the triple bottom line (3BL), the main goals for businesses are to achieve a sustainable strategy, namely environmental, economic and social sustainability. Each aspect of *the* 3BL) is measured according to its impact on profit, people and the planet. For attaining environmental sustainability, companies adopt GPs (Wang *et al.*, 2015). A definition of SM practices as proposed by Roberts and Ball (2014) is, "*the techniques, policies and procedures a firm uses to create manufactured products, that use processes that minimize negative environmental impacts. Conserve energy and natural resources, are safe for employees, consumers and communities are economically sound*".

3.2 The beginning of green practices in manufacturing

As also briefed in the introductory part, the relevance of GPs increases as deteriorating levels of industrial pollution, the depletion of our natural resources and some regulations for the performance of manufacturing industries are observable. GPs in manufacturing were initiated in German in the late 1980s and early 1990s. The Germans established an effective global manufacturing standard to compete globally and which were complying with green regulation of the European market (Rehman and Shrivastava, 2013). The concept of using GPs in the production of items is known as cleaner production. Cleaner production is originated in a conference of the United Nations Environment Program (UNEP) in 1989 (Matos *et al.*, 2018).

3.3 A descriptive examination of available literature

In this section, description analysis of the referred research articles is presented. Detail of referred publications from different academic publishers is given in Table 1. Elsevier is the leading academic publisher with the shortlisted refereed publications for the review of literature in the present study. For the study under examination, most of the articles relevant to the present study are from Elsevier's "Journal of Cleaner Production". Detail of journals of publications under review is given in Table 2. All articles are distributed in the time scale from the year 1987 to2019.

A total of five articles are found in books sections, and three research articles are from conference proceedings. Distribution of research articles per publisher taken in this review is shown in Figure 1(a), which is indicating clearly that articles on the topic GPs are mainly published by Elsevier, Emerald and Taylor and Francis.

3.4 Distribution of research articles across the period/countries

In this section, distribution of refereed articles across the period is analysed. The year-wise research trend is shown in Figure 1(c). This figure clearly directs that the interest of researchers in GPs in manufacturing started to grow between 2010 and2018. Country-wise referred articles are shown in Figure 1(b). Most of the research articles on GPs are from the USA. A total of ten, 15 and 11 research articles are from China, India and the UK, respectively.

3.5 Green practices in manufacturing industries

From the available literature on the concerned topic, it is observed that the interest in GPs in manufacturing is increasing day by day within the research and industrial communities (Deif, 2011). Manufacturing industries have been under growing pressure to incorporate responsible practices across all aspects of their production operations (Ahuja *et al.*, 2019;Bhattacharya *et al.*, 2019;Lartey *et al.*, 2019). Government intervention, market demand and competition pressure have a positive impact on the relation between manufacturing technologies and GPs (Foo *et al.*, 2019). From various research publications in the available literature, several significant GPs are summarised in Table 3. Important aspects of GPs and other related issues have been discussed as follows:

3.5.1 Green design. The concept of green design or "Design for Environment" (DfE) originated in the early 1990s. The scope of the green design includes the objectives of environmental protection, human health and safety and sustainability of natural resources (Lewis *et al.*, 2017). Environmental-conscious design and manufacturing (ECD&M) includes a social and technological aspect of the design of the product. The significance of eco-design was highlighted by Buyukozkan and Cifci (2012), after they observed that around 80% of the environmental impacts of the organisation may be affected during the design process (Laosirihongthong *et al.*, 2013). Benefits of this are cleaner factories, better workers protection, reduced costs of disposal, quality improvements, reduced health risks of workers in the factories, higher productivity and better public image (Zhang *et al.*, 1997). DfE is designing a product in such a way that the probable environmental impacts in all stages of the product life cycle are reduced (Ilgin and Gupta, 2010). ECD&M, DfE and green design are the practices which are resembling each other in the context of environmental viewpoint. Complying to "green design", various tools have been developed and proposed by different researchers such as green design advisor (GDA), ECoDE, producer-based eco-efficiency

S. No	Publisher	No. of referred articles
1	Elsevier	35
2	Emerald	29
3	Taylor and Francis	14
4	Springer	7
5	Inderscience	3
6	IEEE	2
7	Wiley	4
8	Others	9
Total		103

Table 1.
Distribution of referred articles in online database of various publishers

S. No	Name of journals/book/periodicals/report	Type of reference	Academic publishers	Numbers
1	*Journal of Cleaner Production*	Journal article	Elsevier	12
2	*International Journal of Production Research*	-do-	Taylor and Francis	7
3	*International Journal of Operation and Production Management*	-do-	Emerald	5
4	*International Journal of Production Economics*	-do-	Elsevier	3
5	*Supply Chain Management: An International Journal*	-do-	Emerald	3
6	*Industrial Management and Data Systems*	-do-	Emerald	3
7	*Journal of Manufacturing Technology Management*	-do-	Emerald	3
8	*Journal of Operation Management*	-do-	Elsevier	2
9	*Management of Environment Quality: An International Journal*	-do-	Emerald	3
10	*Procedia CIRP*	-do-	Elsevier	2
11	*Procedia Manufacturing*	-do-	Elsevier	2
12	*Procedia Social and Behavioural Science*	-do-	Elsevier	2
13	*Production Planning and Control*	-do-	Taylor and Francis	2
14	*Business Strategy and the Environment*	-do-	Wiley	3
15	*Business Process Management Journal*	-do-	Emerald	1
16	*Chemical Engineering Journal*	-do-	Elsevier	1
17	*Benchmarking: An International Journal*	-do-	Emerald	1
18	*Clean Technology and Environment Policy*	-do-	Springer	1
19	*Construction and Building materials*	-do-	Elsevier	1
20	*Environment Management and Health*	-do-	Emerald	1
21	*European Journal of Purchasing and Supply Management*	Journal article	Elsevier	1
22	*European Journal of Wood and Wood Products*	-do-	Springer	1
23	*Habitat International*	-do-	Elsevier	1
24	*IEEE Transaction on Engineering Management*	-do-	IEEE Xplore	1
25	*International Journal of Computer Integrated Manufacturing*	-do-	Taylor and Francis	1
26	*International Journal of Agile Systems and Management*	-do-	Inderscience	1
27	*International Journal of Green Economics*	-do-	Inderscience	1
28	*International Journal of Life Cycle Assessment*	-do-	Springer	1
29	*International Journal of Logistic Management*	-do-	Emerald	1
30	*International Journal of Quality and Reliability Management*	-do-	Emerald	1
31	*International Journal of Sustainable Development and World Ecology*	-do-	Taylor and Francis	2
32	*Journal of Advance Management Science*	-do-	Others	1
33	*Journal of Economics and Sustainable Development*	-do-	Others	1
34	*Journal of Environment Management*	-do-	Elsevier	1
35	*Management Research Review*	-do-	Emerald	1

Table 2.
Journal wise details of referred articles

(*continued*)

S. No	Name of journals/book/periodicals/report	Type of reference	Academic publishers	Numbers
36	*Journal of Supply Chain Management*	-do-	Wiley	1
37	*Journal of Global Responsibility*	-do-	Emerald	1
38	*Journal of Manufacturing Systems*	-do-	Elsevier	1
39	*Journal of Material Processing Technology*	-do-	Elsevier	1
40	*Journal of Remanufacturing*	-do-	Springer	1
41	*Process Integration and Optimization for Sustainability*	-do-	Springer	1
42	*Management and Marketing*	-do-	Others	1
43	*Resource-Efficient Technology*	-do-	Others	1
44	*Social Responsibility Journal*	-do-	Emerald	1
45	*Resource, Conservation and Recycling*	-do-	Elsevier	2
46	*Sustainability*	-do-	Others	1
47	*World Class Design to Manufacture*	-do-	Emerald	1
48	*World Journal of Entrepreneurship, management and Sustainable Development*	-do-	Emerald	1
49	*Applied Energy*	-do-	Elsevier	1
50	*British Food Journal*	-do-	Emerald	1
51	*Circuit World*	-do-	Emerald	1
52	*Omega*	-do-	Elsevier	1
53	*Transportation Research Part E: Logistics and Transportation Review*	-do-	Elsevier	1
54	*Brundtland Report*	-do-	Others	1
55	*World Review of Science, Technology and Sustainable Development*	-do-	Inder Science	1
56	*Routledge*	Book section	Taylor and Francis	1
57	*IGI Global*	-do-	Others	1
58	*CRC Press*	-do-	Taylor and Francis	1
59	*Green Manufacturing/Springer*	-do-	Springer	2
60	IEEE International conference	Conference proceedings	IEEE Xplore	1
61	10th international conference TMT 2006	-do-	Research Gate	1
62	*Applied Mechanics and Materials*	-do-	Scientific.Net	1
Total				103

Table 2.

(PBEE) and consumer-based eco-efficiency (CBEE) (Ilgin and Gupta, 2010). Kalisvaart and Van Der Horst (1995) have explained different environmental product design tools such as material energy and toxicity (MET), Quick measurement tool to assess ecological impacts (QUEST). Jha (2015) explains that green design includes the analytical techniques for cost minimisation through waste reduction and reducing energy consumption during the manufacturing processes of the items. Selection of material, the type of manufacturing process and geometry is decided in green design of the item, which will satisfy the environmental requirements. Some more practices to promote green design are remanufacturing, reuse, recycling, process substitution, disposal or treatment of manufacturing wastes (Rehman and Shrivastava, 2013).

3.5.2 Life cycle assessment. Life cycle assessment (LCA) is a significant GP which is being implemented by some manufacturing companies, which are serious towards environment problems such as PUMA, Kering group, Stella McCartney, Novo Nordisk and Arla group, etc.(Lauesen, 2018). LCA is a methodology that is employed to evaluate the environmental impact and usage of resources throughout the life cycle of a product (Vieira *et al.*, 2016). LCA

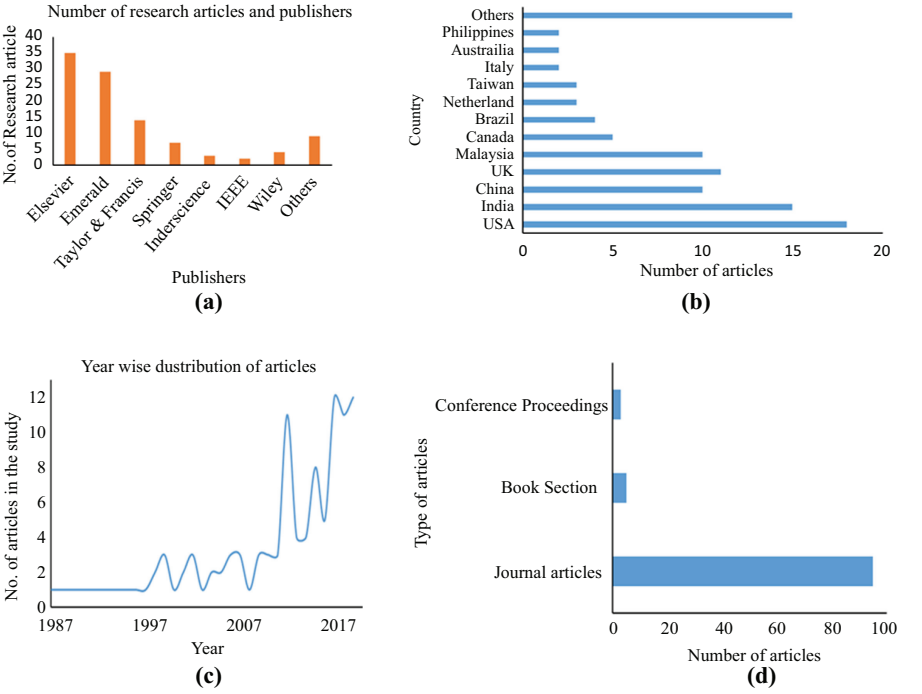

Figure 1.
(a) The number of referred articles per journals, (b) country-wise distribution of articles, (c) year-wise trend, (d) proportion of journal articles, book sections and conference proceeding's papers

provides an account of the environmental effect of the firm's products and processes, but social and economic influences have also been combined into this (Lauesen, 2018). "Product life cycle assessment", "life-cycle analysis", "Eco balances, resource and environmental profile analysis (REPA)", "product line analysis" and "integrated chain management" are some synonymous terms of LCA (Curran, 1996). For environment conscious design or DfE, the life cycle of the product must be well understood, and so, the designer can change the raw material or substances at the time of manufacturing of the product. Thus, LCA facilitates for systematically gathering, testing and presentation of environmental data (Rehman and Shrivastava, 2013).

Some researchers integrated life cycle costing (LCC) into life cycle analysis (LCA). LCA is a method which is used to evaluate the impacts on the environment through product's life cycle from raw material to final disposal (Ilgin and Gupta, 2010), whereas LCC studies several aspects of costs for all steps in the product's life cycle. Such a type of tool which integrates both LCA and LCC is named as green quality function deployment-II (GQFD-II), and it can be used for evaluating different concepts of product in the context of quality, environment and costs (Zhang, 1999).

3.5.3 Natural resource conservation and energy conservation. In 1992, in Rio de Janeiro, the Earth Summit and subsequent events which were focussed on the 3BL – people, planet and profit – have spread the awareness about the natural environment at the global level. So, various natural environment standards have emerged. But, despite awareness, such standards are violated to enhance the economic activities in the manufacturing sector (Mishra and Suar, 2013). Teles *et al.* (2015) concluded in their study that reduced consumption of natural resources is a popular GP in Brazilian companies.

Green practices in manufacturing industries	References/source
1) Adoption of treatment of solid waste	Van Hoek (1999), Arena *et al.* (2003), Zhu and Sarkis (2004), Rao and Holt (2005), Jawahir *et al.* (2006), Rusinko (2007), Zhu and Sarkis (2007), Ratnasingam and Wagner (2009), Hu and Hsu (2010), Millar and Russell (2011), Tseng and Chiu (2012), De Vries *et al.* (2012), Prajogo *et al.* (2012), Zubir *et al.* (2012), Jayaraman *et al.* (2012), Rosen and Kishawy (2012), Laosirihongthong *et al.* (2013), Büyüközkan and Çifçi (2012), Tilina *et al.* (2014), Nordin *et al.* (2014), Gupta *et al.* (2015); Teles *et al.* (2015), Jabbour *et al.* (2016), Abdullah *et al.* (2017), Shankar *et al.* (2017), Bhanot *et al.* (2017), Islam *et al.* (2017); Wu *et al.* (2017), Muñoz-Villamizar *et al.* (2018), Shubham *et al.* (2018), Ali *et al.* (2018), Kaur *et al.* (2018), Sellitto (2018), Nobrega *et al.* (2019), Choudhary and Sangwan (2019), Hu *et al.* (2019), Tseng *et al.* (2019), Shao and Ünal (2019), Leong *et al.* (2019), Green *et al.* (2019)
2) Better use of heat from the oven used in manufacturing plant	
3) By means of treatment of effluents from plant	
4) Caring about employee's health and safety during manufacturing	
5) Changing cleaning processes during manufacturing	
6) Clean production	
7) Designing of products to reducing consumption of material and energy	
8) Disclosure about environment liabilities in public balanced sheet	
9) Eliminating steps in production processes	
10) Emission filters and pollution controls at the end of the	
11) Employing renewable material and energy	
12) Enhanced capacity utilisation	
13) Environmental auditing for suppliers	
14) Expand effectiveness of environmental policy	
15) Gaining production efficiency	
16) Green design	
17) Green procurement	
18) Increasing energy efficiency	
19) Internal consumption	
20) Internal recycling of wastes	
21) Joining local recycling organisation	
22) Less consumption of energy and fuel	
23) Less consumption of natural sources	
24) Managing the environment internally	
25) Minimum waste generation and reducing environmental pollution	
26) No use of hazardous material during manufacturing activities	
27) Option to use ecological lubricant	
28) Organising seminars and workshops on environmental awareness to stakeholders	
29) Participation in environmental management systems such as ISO 14001 certification	
30) Prevention instead of treatment	
31) Product life assessment production process	
32) Promoting 6R (reduce, reuse, recycle, recover, redesign, remanufacture)	
33) Redesigning process to improve sustainability	
34) Reduce emissions	
35) Remanufacturing	
36) Renewable rather than depleting	
37) Reuse, recycle and recovery of materials	
38) Reverse logistics	
39) Sending a house auditor to appraise environmental performance	
40) Supply should be equal to the demand	
41) The increased amount of goods delivered on time	

(*continued*)

Table 3.
A comprehensive list of green practices in manufacturing industries based on the existing literature

Green practices in manufacturing industries	References/source
42) Training of employees about using environmentally conscious activities	
43) Usage of "Life Cycle Assessment (LCA)" for solid waste management	
44) Usage of renewable source of energy	
45) Using advance material and process	
46) Using cleaner technology	
47) Using environment-friendly substitutes of toxic inputs	
48) Using of environment-friendly technology	
49) Using of green logistic	
50) Using of sustainable materials	
51) Using waste to energy technology	
52) Utilise biomass energy	
53) Zero waste manufacturing	

Table 3.

Over one-third of all energy is consumed in industrial activities. Also, it is one of the most significant factors influencing the overall costs of manufacturing in many of the industries. Therefore, it is vitally important to make sure that the workable technique is being used to reduce the consumption of energy within manufacturing facilities (Goosey and Kellner, 2010). Total energy consumption of the world is doubled over the last 60 years because the world is observing fast growth of manufacturing industries for meeting the stringent demands of customers for different products (Garg *et al.*, 2015). In Indian manufacturing industries, energy consumption is enormous and coping with the situation of reduction in energy consumption is one of the key challenges. Energy consumed per unit output in reference to industrial activities is called energy intensity, and this energy intensity of India is amongst the highest in the world (Soni *et al.*, 2017). In China, 70% of the total primary energy is consumed by the industrial sector only; hence, China's government is paying more attention to energy efficiency improvement (Li and Lin, 2016).

The benefits of energy-saving in manufacturing activities are not only limited to economic benefits but also having very important reductions in environment emissions (Fahad *et al.*, 2017). If energy generation is through thermal plants, then obviously more carbon emissions are there in the natural environment due to the burning of coal. Manufacturing community need to be at the vanguard of responding to global sustainability challenges due to adverse environmental impacts of manufacturing activities (Owodunni, 2017).

3.5.4 Green practices in supply chain management. When environmental concerns are integrated into the management of supply chain activities of the firm, it is stated as "green supply chain management" (GSCM) (Sarkis, 2012). For enhancing of environmental performance of industries, the concept of "green supply chain management" is proposed by the researchers from academicians as well as from industry. This concept originated way back in the early 1990s, but the popularity of this concept is grown after 2000 (Fahimnia *et al.*, 2015). Green practices in this GSCM, which can be further called as "green supply chain practices" (GSCPs) are very important for any firm interested to increase its green performance.

GPs in the supply chain are the collaboration with suppliers to decrease the usage of hazardous materials (Tseng *et al.*, 2016), internal management support, collaboration with customers and suppliers, eco-design and investment recovery (Zhu and Sarkis, 2004). Reverse logistics, industrial symbiosis, carbon management, green design, ISO 14001 certification, green warehousing, green purchasing, green outsourcing are other noteworthy GPs in supply

chain management. Further, Zhu *et al.* (2005) stated that green policies also include "sale of waste inventories", "the selling of scrapped and used materials", "environmental audit programs" and the general quality control of the environment.

3.5.5 Green procurement. Cost, quality and delivery are three such criteria which are focussed primely in traditional purchasing or procurement. But, in "green procurement" or "green purchasing", in addition to three traditional criteria, environmental issues are also considered at the time of procurement decision of the firms (Ghosh, 2018). Green procurement (or purchasing) can be defined as an environmentally conscious purchasing practice which minimises the source of waste and promotes recycling and recovery of purchased materials without adversely affecting the performance of these materials (Min and Galle, 2001); (Zsidisin and Siferd, 2001). Green procurement may improve the efficiency of resource utilisation and operation, which in turn would improve the financial performance of the organisation (Song *et al.*, 2017). Green procurement involves setting priorities and introducing procedures and certifications for vendors while also taking environmental concerns into account when making purchasing decisions (Schmidt *et al.*, 2017).

Adoption of green procurement improves the environmental and financial performance of the manufacturing firms (Zhu and Sarkis, 2004). Many results have proved that by using green procurement, marked improvements in environmental performance can be made (Zsidisin and Hendrick, 1998; Green *et al.*, 1998) as well as business performance (Carter *et al.*, 2000; Bin *et al.*, 2008). Many organisations started for green procurement, such as, a Japanese company "Fujitsu Group" had initiated a campaign to buy environmentally friendly parts, materials and products with the support of their business partners as a part of their "only green procurement policy" (Ali *et al.*, 2018). An organisation having large purchasing volume is more heavily involved in practising green procurement than one with small purchasing volume. Moreover, the firms which take environmental regulatory obedience more seriously tend to adopt green procurement more actively than the others (Min and Galle, 2001). But some authors like Khan *et al.* (2019) have concluded that green procurement has a limited effect on estimating the performance of industries of developing countries due to the lack of green suppliers in these developing countries.

3.5.6 Green disposal (waste minimisation). Wastes minimisation is using managing methods for systematically reducing emissions to land, water and air (Bates and Phillips, 1999). Waste management can be measured as natural resources management so that present and future beneficial uses are not weakened (Englande and Jin, 2006). The process of waste management is generally defined by the waste management hierarchy. This hierarchy signifies how to manage waste, and this comprises different methods like recycle, reduce, reuse and lastly, disposal of waste (Sushil, 1990). These waste managing methods framed in the hierarchical relations are defined according to the best mode to manage waste without any destruction to the environment. Instead of the disposal of waste in a landfill, the hierarchical representation of waste management promotes reuse and recycling (Wilson *et al.*, 2006). Another more important priority expected to yield long-term benefits is waste management schemes, where waste materials and resources are used as inputs to other manufacturing processes (Paulraj, 2009).

This "waste management hierarchy" is summarised as *Elimination, Reduction, Reuse, Recovery* and finally, *Disposal. Elimination* step considers the total removal of wastes by using radical process changes, *reduction* step is the minimisation or lessening of waste at source, *reuse* stage comprises putting items back into use, in *recovery* recovering the value or energy from the waste materials and *disposal* is the last option for waste management which must be least prioritised (Bates and Phillips, 1999).

Serious worries are before us concerning the outcome of easing of the import of recyclable industrial wastes on India. Many of the rivers, lakes and coastal environments have been polluted by industrial effluents. Too diminutive attention has been paid to control the

disposal of hazardous industrial wastes to prevent risk to people or outflow to the environment (Chaudhary *et al.*, 2002). In various manufacturing industries, toxic materials are extensively used for product development and process operations. A wide variety of toxic chemicals are involved in many manufacturing operations for cleaning, catalysing, etching, etc. Such chemicals lead to waste generation from the processes. According to a study in the USA, the toxic release inventory (TRI) statistics showed that a large amount of toxic chemicals is released annually into the environment by manufacturing as well as other industrial sectors. These chemicals cause a significant impact on the health of the public and on the eco-system (Dornfeld *et al.*, 2013).

4. Findings and discussions

On the basis of the review of available literature on GPs, Table 4 summarises valuable insights by some researchers. This paper finds that the manufacturing firms need an environmentally safe and economically stable system to meet the emerging challenges. Since there is increasing interest in environmental issues, green initiatives are now becoming part of a number of industrial policies (Despeisse *et al.*, 2012). Various GPs, tools and indicators are discussed to fulfil the needs of GM or ECM. It is clear that the usage of GPs increases the environmental and social performance of the manufacturing industries. Despite the serious environmental issues before us, numerous organisations are still sceptical about their business benefits of GPs (Muñoz-Villamizar *et al.*, 2018). Several of the managers of manufacturing companies still perceive "reducing environmental waste" not as a competitive opportunity but as a "necessary evil", just to avoid legal restrictions (Tilina *et al.*, 2014). But the issue of using GPs in manufacturing activities is very significant to save the environment, especially in Asian countries because the most of world's items will be manufactured in Asian countries in next couple of decades (Zhu and Sarkis, 2004).

Indian manufacturing companies are also shifting forward from "conformance to performance" and are becoming serious towards comprehensively implementing GPs and not just pollution prevention (Rehman *et al.*, 2016). The top companies in India which are implementing GPs in their operations are (1) Suzlon Energy, (2) ITC Limited, (3) Tata Metaliks Limited (TML), (4) Tamil Nadu Newsprint and Papers Limited (TNPL), (5) Wipro Technologies, (6) HCL Technologies, (7) Oil and Natural Gas Company (ONGC), etc. (Ramayah *et al.*, 2012). Certainly, increasing profit is the greatest purpose of any manufacturing company. Environmental performance of organisations is also dependent on their site, type of raw material and production processes used (Muñoz-Villamizar *et al.*, 2018).

There are some hurdles in bringing out GPs in manufacturing industries. Many authors have identified different drivers and barriers to using GPs in firms. For example, Ghazilla *et al.* (2015) have recognised 39 drivers and 64 barriers to bring out GPs in Malaysian manufacturing industries. GPs may still have a hard time by manufacturing firms if they are focussing to give environmental benefits only and less in improving business improvement of the manufacturing organisation (Zhan *et al.*, 2018).

Hopefully, the research trend in the area of GPs of manufacturing will remain to continue in an upward direction in the coming years as more and more researchers from academic as well as from industries are taking interest in this area.

5. Conclusions, limitations and future scope

This study reviews earlier works to offer a clear approach to GPs. It is learnt that many researchers have studied different aspects of environmental issue in manufacturing

S. No	Authors	Findings
1	Abdullah *et al.* (2017)	A survey was conducted in Malaysian palm oil mills. Authors have shown in the study that employee's well-being has the highest level in terms of both priorities as well as current successes. The current achievement of the sustainable practices in the Malaysian palm oil mills is slightly lower than the priority given to them
2	Abdul-Rashid *et al.* (2017)	The study indicates that the manufacturing process is the stage where the improvement of the sustainability performance of the industry can be done. This study found that manufacturing companies in Malaysia are highly focussed on the production bound when applying sustainable practices in manufacturing industries
3	Ali *et al.* (2018)	In this study, a survey was conducted in Indian manufacturing industries. The study concluded that the manufacturing organisations in plastic, steel, automotive and machinery clearly have a stronger commitment towards a cleaner and greener development, and they are dominant in energy and environmental efficiency
4	Bates and Phillips (1999)	This paper demonstrated the benefits of waste management practices in the food and drink industries. Food and drink industries following waste minimisation will exploit the benefits in terms of financial as well as environmental
5	Bhanot *et al.* (2017)	Different enablers and barriers to the implementation of sustainable manufacturing are analysed. Pressure from the market, government regulations, economic benefits, lowering manufacturing costs, quality improvements, education and training are enablers for implementing sustainable practices in manufacturing in India. While on the other hand, lack of awareness, negative attitudes, lack of funds for green initiatives, lack of standard metrics for performance measuring, power shortage are the barriers to the adoption of these practices
6	Bigliardi and Bottani (2012)	This article provided a picture of the adoption of environmentally friendly practices. Some useful guidelines for companies wishing to undertake environmental initiatives are also provided through this study. Implementations of green practices by fashion manufacturers in Italy are quite limited. With a very limited number of customers sensitive to environmental issues is also perceived as barriers to implementing green manufacturing practices
7	Bin *et al.* (2008)	Research revealed that green purchasing practices may promote enterprise's negative financial performance, environmental performance and operational performance in Chinese enterprises, but some negative influence is detected on positive performance, at least in short time
8	Carter *et al.* (2000)	The study revealed that there is a positive effect on the firm's financial performance after applying environment-friendly purchasing practices. So, managers should focus on such activities in the firm to improve the financial performance of the industries
9	(Chaudhary *et al.*, 2002)	In this study, a survey is performed in India. Although the growing population and rapid urbanisation are enhancing India's environmental problem, unplanned industrialisation is also a major reason for Indian environmental problem. The authors have attempted to highlight water pollution due to industrial activities. If green practices will be implemented, then this type of water pollution may be reduced
10	Dorantes *et al.* (2018)	The study concluded that factors such as nature conservation, the protection of the economic and social well-being and the sustainable future for humanity urge the adoption of the green culture in industries. Green procurement is a critical activity to produce a sustainable product. European and Asian countries have been involved heavily for making green policies

(*continued*)

Table 4.
Some insights from the literature on green practices

S. No	Authors	Findings
11	Ghazilla *et al.* (2015)	Authors classified the drivers of green manufacturing practices into legislation, organisation style, eco-knowledge, business environment, society influences, financial incentives and innovations. Under these subheads, 39 types of drivers are listed which motivate the implementation of green manufacturing practices. Similarly, barriers in the implementation of green practices are classified into organisational, environmental knowledge, business environment, social influence, local government legislation, technology, financial and supplier. Authors revealed 64 types of barriers to the adoption of green manufacturing practices
12	Govindan *et al.* (2014)	47 barriers of implementing green practices in supply chain management are identified and grouped into outsourcing, technology, knowledge, financial and involvement and support. As per this study, technology barriers are most important, so industries need to concentrate on technological development
13	Ilgin and Gupta (2010)	In this review paper on environmentally conscious manufacturing and product recovery (ECMPRO), it is concluded that environmental issues in manufacturing have a growing approval amongst researchers. Authors suggested that environmentally conscious manufacturing principles should be incorporated into the curriculum of engineering at the university level
14	Inman and Green (2018)	In this study, the collective influence of lean and green concepts on the operational and environmental performance of the industries was analysed. The study concluded that lean manufacturing practices are positively connected with the environmental performance of the manufacturing industries in the USA. They found that if green practices are integrated with lean practices, then environmental as well as operational performance may be improved
15	Islam *et al.* (2017)	In this review paper, a comprehensive list of different green aspects and practices in green supply chain management is presented. The researchers have summarised 58 green practices and aspects in green supply chain management. These set of practices are categorised into different subheads. In subhead of green manufacturing, seven practices were identified through the literature survey
16	Matos *et al.* (2018)	A list of benefits of cleaner production practices and difficulties to adopt these clean production practices are presented in this review paper. Reduction of pollution and wastes, productivity improvement, new business opportunity, improvement of the organisational image, improvement in the work environment and technological update of the productive process are the benefits of cleaner production. Difficulties for adopting cleaner production practices are lack of clear guidelines, inappropriate record 19keeping, unavailability of resources, withdrawal of implementing green of implanting project, short-term investment, absence of participation of employees, inadequate planning, conflicts between stakeholders, inadequate communication, more complexity in operation, absence of environmentally friendly culture, difficulty of receiving market feedback' difficulties
17	Millar and Russell (2011)	The authors examined the practices in manufacturing at five Caribbean countries, namely, Trinidad and Tobago, Jamaica, Guyana, St Lucia and Barbados. They ascertained that Caribbean manufacturers need more awareness and training so that they can exploit the potential for competitiveness by focussing on sustainability practices. Caribbean manufacturers are interested in learning more about sustainable

Table 4. (*continued*)

S. No	Authors	Findings
		manufacturing practices. Authors concluded that government agencies and manufacturing network can play an inspiring role to bring out sustainable practices in manufacturing operations
18	Montabon *et al.* (2007)	Researchers identified six significant environment management practices (EMPs) after content analysis of firms. These six practices are recycling, proactive waste reduction, remanufacturing, environmental design, specific design targets, surveillance of the market for environmental issues. An innovation data collection technique, that is, content analysis, is highlighted in this research study
19	Nobrega *et al.* (2019)	Authors have listed sustainable practices in the manufacturing processes. Various green practices have been highlighted in processes of metal forming, heat treatment, casting, electrostatic painting and welding. Authors concluded that there are many practices that can be applied in each process. However, in several of those practices, issues relating to better use of resources and energy conservation are illustrated
20	Rehman *et al.* (2016)	Authors have formulated a GM model based on the survey data from Indian manufacturing industries. The study analysed the relationship between green manufacturing's success factors and performance metrics by applying regression and correlation analysis
21	Rehman and Shrivastava (2013)	In this review paper on green manufacturing, authors concluded that green manufacturing involves everything a business does those impacts the environment. As per the authors, more research and analysis are needed by utilising various tools for exploring green concepts in manufacturing
22	Sangwan and Mittal (2015)	Authors has revealed in this literature review paper that green manufacturing (GM), environmentally conscious manufacturing (ECM); environmentally responsible manufacturing (ERM); environmentally benign manufacturing (EBM), sustainable manufacturing (SM), clean manufacturing (CM), cleaner production (CP) and sustainable production (SP) have been used interchangeably by researchers which requires standardisation
23	Shankar *et al.* (2017)	Researchers have portrayed a list of 22 sustainable manufacturing practices. Amongst these 22 sustainable practices, 6R (reduce, reuse, recycle, recover, redesign, remanufacture) concept is most significant. A framework is also proposed in this study
24	Teles *et al.* (2015)	Authors applied cluster analysis on a surveyed data on 643 Brazilian companies to check the performance of different environmental management practices. Reducing the consumption of natural resources and improved waste treatment are such practices which are associated with the best performance in Brazilian companies under this study. It is also highlighted that better performance of environmental management practices is connected with large industrial companies
25	Wang *et al.* (2015)	According to the authors, dominant green practices in the auto industry are recycling of raw materials, measuring a company's carbon dioxide footprints, use of fuel-efficient tools and machines, selecting recyclable packaging material. Economic performance indicators of sustainable manufacturing practices are operational, inventory and environmental costs. Environmental performance indicators are business waste, green image, CO_2 emissions. Further, they revealed social performance indicators of sustainable manufacturing practices are wealth created, technology improvement and health and safety

Table 4.

industries. Only recently have some researchers attempted to propose some GPs in manufacturing industries. Some researchers have proposed various green techniques and practices to lessen the environmental impacts in manufacturing industries. This paper attempts to gather significant GPs in various activities of manufacturing. After reviewing the relevant literature, this study gathered a comprehensive list of GPs in manufacturing industries. The authors of this article hope that the list of GPs in the present study will offer benefits to researchers for further research on GPs in the manufacturing industry. Further, this paper also explores the trend of publication of scholarly articles on GPs. This study concludes that the majority of articles in this area have been published over the last 10 years. The study found that most of the authors belong to the USA, but India is also a leading light of developing countries in the area of research publications on GPs. So, it has been concluded that research on GPs is emerging at a fast pace around the world. It is expected that this paper will set a direction in the progress of future researching and developing in the area of green strategies in manufacturing industries.

The present study has some limitations also. First, it is possible that this study might have missed a relevant offline database as this study used only online databases to find the relevant literature. Second, this study has not chosen a subjective overview for screening and selecting the research articles as the study has collected relevant research articles using some selected keywords only. Furthermore, the identification of GPs is based on literature related to various types of industries.

For further study, researchers should emphasis on gathering industry-specific GPs. This paper suggests to use a different search method to find more literature in this area. For future research, this study suggests to assess the effect of GPs on operational performance as well as the environmental performance of the manufacturing industries by using empirical analysis. Hurdles and facilitating factors to apply GPs in manufacturing industries may also be identified and analysed for the future study. There is also a scope to develop a suitable model to apply the GPs in manufacturing industries. Interrelationships of the GPs described in this study can also be investigated using the relevant multi-criteria decision analysis (MCDA) tool.

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